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ASHRAE 90.1 (2007), Energy Standard for Buildings Except Low-Rise Residential Buildings, Addendum, as mandated by and incorporated by the States and Municipalities including Illinois, California, and the Code of Federal Regulations at 10 CFR 433.4.

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**ANSI/ASHRAE/IESNA Addenda a, b, c, g, h, i, j, k, l, m, n, p, q, s, t, u, w, y, ad, and aw to ANSI/ASHRAE/IESNA Standard 90.1-2007**

# ASHRAE ADDENDA

**2008 SUPPLEMENT**

# Energy Standard for Buildings Except Low-Rise Residential Buildings

See Appendix for approval dates.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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**NOTE**

**When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at www.ashrae.org.**


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## FOREWORD

*Efficiency and certification requirements for open cooling towers were first incorporated into the 2001 edition of Standard 90.1. At the time, closed circuit cooling towers were known as "fluid coolers" with no established certification program and were not covered by these requirements. Since then, however, fluid coolers have become known as "closed circuit cooling towers" and the Cooling Technology Institute adopted a certification standard that covers this equipment. This has led to confusion in the industry with consulting engineers and inspectors on occasion trying to apply the current open circuit cooling tower requirements in the standard to closed circuit cooling towers. This addendum seeks to clarify that the current cooling tower requirements in the standard apply to open circuit cooling towers only, until such time that separate requirements for closed circuit cooling towers are established in the standard.*

Note: In this addendum, changes to the current standard are indicated in the text by *underlining* (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum a to 90.1-2007

*Revise Table 6.8.1G as follows (I-P units):*

**TABLE 6.8.1G Performance Requirements for Heat Rejection Equipment**

| Equipment Type [d] | Total System Heat Rejection Capacity at Rated Conditions | Subcategory or Rating Condition | Performance Required[a,b] | Test Procedure[c] |
|---|---|---|---|---|
| Propeller or Axial Fan Open Cooling Towers | All | 95°F Entering Water<br>85°F Leaving Water<br>75°F wb *Outdoor air* | 38.2 gpm/hp | CTI ATC-105 and CTI STD-201 |
| Centrifugal Fan Open Cooling Towers | All | 95°F Entering Water<br>85°F Leaving Water<br>75°F wb *Outdoor air* | 20.0 gpm/hp | CTI ATC-105 and CTI STD-201 |
| Air-Cooled Condensers | All | 125°F Condensing Temperature<br>R-22 Test Fluid<br>190°F Entering Gas Temperature<br>15°F Subcooling<br>95°F Entering db | 176,000 Btu/h·hp | ARI 460 |

[a] For purposes of this table, *open cooling tower performance* is defined as the ~~maximum~~ flow rating of the tower at the thermal rating condition listed in Table 6.8.1G divided by the fan nameplate rated motor power.

[b] For purposes of this table, *air-cooled condenser performance* is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

[c] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[d] The efficiencies for open cooling towers listed in Table 6.8.1G are not applicable for closed-circuit cooling towers.

*Revise Table 6.8.1G as follows (S-I units):*

**TABLE 6.8.1G Performance Requirements for Heat Rejection Equipment**

| Equipment Type [d] | Total System Heat Rejection Capacity at Rated Conditions | Subcategory or Rating Condition | Performance Required[a,b] | Test Procedure[c] |
|---|---|---|---|---|
| Propeller or Axial Fan Open Cooling Towers | All | 35°C Entering Water<br>29°C Leaving Water<br>24°C wb *Outdoor air* | 3.23 L/s·kW | CTI ATC-105 and CTI STD-201 |
| Centrifugal Fan Open Cooling Towers | All | 35°C Entering Water<br>29°C Leaving Water<br>24°C wb *Outdoor air* | 1.7 L/s·kW | CTI ATC-105 and CTI STD-201 |
| Air-Cooled Condensers | All | 52°C Condensing Temperature<br>R-22 Test Fluid<br>88°C Entering Gas Temperature<br>8°C Subcooling<br>35°C Entering db | 69 COP | ARI 460 |

[a] For purposes of this table, *open cooling tower performance* is defined as the ~~maximum~~ flow rating of the tower at the thermal rating condition listed in Table 6.8.1G divided by the fan nameplate rated motor power.

[b] For purposes of this table, *air-cooled condenser performance* is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

[c] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[d] The efficiencies for open cooling towers listed in Table 6.8.1G are not applicable for closed-circuit cooling towers.

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## FOREWORD

*Some facilities covered by Standard 90.1 are challenged to demonstrate compliance with fan power limitations requirements of Standard 90.1 while including design features protecting the safety of inhabitants and compliance of other applicable standards, codes, laws, or regulations. These facilities often require compliance with NIH, NFPA, and other standards with air control and conditioning more stringent than Standard 90.1 and 62.1 requirements. An example of these facilities is vivariums. In exception section 6.5.2.3 (a) of Standard 90.1-2004, the reference to the requirements of Standard 62.1 as the minimum ventilation required is an example of this conflict. This addendum corrects the reference by eliminating the specific section and denoting only Standard 62.1 and allows for another, higher outdoor ventilation rate to be set by the regulating body for these specific applications.*

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum b to 90.1-2007

*Revise the exceptions in Section 6.5.2.3 as follows (I-P and S-I units):*

**6.5.2.3**

**Exceptions:**

a. The system is capable of reducing supply air volume to 50% or less of the design airflow rate or the minimum outdoor air ventilation rate specified in ~~6.2 of~~ ASHRAE Standard 62.1 or other applicable federal, state or local code or recognized standard, whichever is larger, before simultaneous heating and cooling takes place.

*The remainder of Section 6.5.2.3 remains unchanged.*

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## FOREWORD

*Some facilities covered by Standard 90.1 are challenged to demonstrate compliance with fan power limitations requirements of Standard 90.1 while including design features protecting the safety of inhabitants and compliance of other applicable standards, codes, laws, or regulations. These facilities often require compliance with NIH, NFPA, and other standards with air control and conditioning more stringent than Standard 90.1 and 62.1 requirements. An example of these facilities is vivariums. In ASHRAE Standard 90.1-2004 Section 6.5.2.3, Exception (d), this application was not included. This addendum adds vivariums to the list of spaces that require specific humidity levels to satisfy process needs.*

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum c to 90.1-2007

*Revise the exceptions in Section 6.5.2.3 as follows (I-P and S-I units):*

**6.5.2.3**

**Exceptions:**

d. Systems serving spaces where specific humidity levels are required to satisfy process needs such as vivariums, museums, surgical suites and buildings with refrigerating systems such as supermarkets, refrigerated warehouses and ice arenas. This exception also applies to other applications for which fan volume controls in accordance with Exception (a) are proven to be impractical to the enforcement agency.

*The remainder of Section 6.5.2.3 remains unchanged.*

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## FOREWORD

*This addendum updates the building envelope criteria for metal buildings for the first time since Standard 90.1-1999. Other envelope criteria were updated through addenda as and at to Standard 90.1-2004.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum g to Standard 90.1-2007

*Revise the standard as follows ( I-P and SI units):*

*Add the following definition to Section 3.2:*

***liner system (Ls):*** a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members.

*Add the following abbreviation to Section 3.3:*

Ls liner system

*Modify Section 5 as follows (I-P units):*

**TABLE 5.5-1 Building Envelope Requirements For Climate Zone 1 (A, B)***

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.063 | R-15.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.218 | R-3.8 ci |
| Metal Building[a] | U-0.065 | R-19.0 | U-0.065 | R-19.0 | ~~U-1.280~~ U-0.167 | ~~NR~~ R-6.0 |
| Attic and Other | U-0.034 | R-30.0 | U-0.027 | R-38.0 | U-0.081 | R-13.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.580 | NR | U-0.151[ab] | R-5.7 c.i.[ab] | U-0.580 | NR |
| Metal Building | ~~U-0.113~~ U-0.093 | ~~R-13.0~~ R-16.0 | ~~U-0.113~~ U-0.093 | ~~R-13.0~~ R-16.0 | ~~U-1.180~~ U-0.113 | ~~NR~~ R-13.0 |
| Steel-Framed | U-0.124 | R-13.0 | U-0.124 | R-13.0 | U-0.352 | NR |
| Wood-Framed and Other | U-0.089 | R-13.0 | U-0.089 | R-13.0 | U-0.292 | NR |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-1.140 | NR | C-1.140 | NR | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.322 | NR | U-0.322 | NR | U-0.322 | NR |
| Steel-Joist | U-0.350 | NR | U-0.350 | NR | U-0.350 | NR |
| Wood-Framed and Other | U-0.282 | NR | U-0.282 | NR | U-0.282 | NR |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.730 | NR | F-0.730 | NR | F-0.730 | NR |
| Heated | F-1.020 | R-7.5 for 12 in. | F-1.020 | R-7.5 for 12 in. | F-1.020 | R-7.5 for 12 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.700 | | U-0.700 | | U-0.700 | |
| Nonswinging | U-1.450 | | U-1.450 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-1.20 | | U-1.20 | | U-1.20 | |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-1.20 | SHGC-0.25 all | U-1.20 | SHGC-0.25 all | U-1.20 | SHGC-NR all |
| Metal framing (entrance door)[~~e~~d] | U-1.20 | | U-1.20 | | U-1.20 | |
| Metal framing (all other)[~~e~~d] | U-1.20 | | U-1.20 | | U-1.20 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.98 | $SHGC_{all}$–0.36 | $U_{all}$–1.98 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.98 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$–0.16 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.90 | $SHGC_{all}$–0.34 | $U_{all}$–1.90 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.90 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.36 | $SHGC_{all}$–0.36 | $U_{all}$–1.36 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.36 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[ab]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~e~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-2 Building Envelope Requirements For Climate Zone 2 (A, B)*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.218 | R-3.8 c.i. |
| Metal Building[a] | ~~U-0.065~~<br>U-0.055 | ~~R-19.0~~<br>R-13.0 + R-13.0 | ~~U-0.065~~<br>U-0.055 | ~~R-19.0~~<br>R-13.0 + R-13.0 | ~~U-0.167~~<br>U-0.097 | ~~R-6.0~~<br>R-10.0 |
| Attic and Other | U-0.027 | R-38.0 | U-0.027 | R-38.0 | U-0.081 | R-13.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.151[ab] | R5.7 c.i.[ab] | U-0.123 | R-7.6 c.i. | U-0.580 | NR |
| Metal Building | ~~U-0.113~~<br>U-0.093 | ~~R-13.0~~<br>R-16.0 | ~~U-0.113~~<br>U-0.093 | ~~R-13.0~~<br>R-16.0 | ~~U-0.184~~<br>U-0.113 | ~~R-6.0~~<br>R-13.0 |
| Steel-Framed | U-0.124 | R-13.0 | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.124 | R-13.0 |
| Wood-Framed and Other | U-0.089 | R-13.0 | U-0.089 | R-13.0 | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-1.140 | NR | C-1.140 | NR | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.107 | R-6.3 c.i. | U-0.087 | R-8.3 c.i. | U-0.322 | NR |
| Steel-Joist | U-0.052 | R-19.0 | U-0.052 | R-19.0 | U-0.069 | R-13.0 |
| Wood-Framed and Other | U-0.051 | R-19.0 | U-0.033 | R-30.0 | U-0.066 | R-13.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.730 | NR | F-0.730 | NR | F-0.730 | NR |
| Heated | F-1.020 | R-7.5 for 12 in. | F-1.020 | R-7.5 for 12 in. | F-1.020 | R-7.5 for 12 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.700 | | U-0.700 | | U-0.700 | |
| Nonswinging | U-1.450 | | U-0.500 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[bc] | U-0.75 | | U-0.75 | | U-1.20 | |
| Metal framing (curtainwall/storefront)[cd] | U-0.70 | SHGC-0.25 all | U-0.70 | SHGC-0.25 all | U-1.20 | SHGC-NR all |
| Metal framing (entrance door)[cd] | U-1.10 | | U-1.10 | | U-1.20 | |
| Metal framing (all other)[cd] | U-0.75 | | U-0.75 | | U-1.20 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.98 | $SHGC_{all}$–0.36 | $U_{all}$–1.98 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.98 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.90 | $SHGC_{all}$–0.39 | $U_{all}$–1.90 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.90 | $SHGC_{all}$–0.34 | $U_{all}$–1.90 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.36 | $SHGC_{all}$–0.36 | $U_{all}$–1.36 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.36 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[ab]Exception to Section A3.1.3.1 applies.
[bc]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[cd]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

**TABLE 5.5-3 Building Envelope Requirements For Climate Zone 3 (A, B, C)***

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.173 | R-5.0 c.i. |
| Metal Building[a] | ~~U-0.065~~ U-0.055 | ~~R-19.0~~ R-13.0 + R-13.0 | ~~U-0.065~~ U-0.055 | ~~R-19.0~~ R-13.0 + R-13.0 | U-0.097 | R-10.0 |
| Attic and Other | U-0.027 | R-38.0 | U-0.027 | R-38.0 | U-0.053 | R-19.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.123 | R-7.6 c.i. | U-0.104 | R-9.5 c.i. | U-0.580 | NR |
| Metal Building | ~~U-0.113~~ U-0.084 | ~~R-13.0~~ R-19.0 | ~~U-0.113~~ U-0.084 | ~~R-13.0~~ R-19.0 | ~~U-0.184~~ U-0.113 | ~~R-6.0~~ R-13.0 |
| Steel-Framed | U-0.084 | R-13.0 + R-3.8 c.i. | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.124 | R-13.0 |
| Wood-Framed and Other | U-0.089 | R-13.0 | U-0.089 | R-13.0 | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-1.140 | NR | C-1.140 | NR | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.107 | R-6.3 c.i. | U-0.087 | R-8.3 c.i. | U-0.322 | NR |
| Steel-Joist | U-0.052 | R-19.0 | U-0.052 | R-19.0 | U-0.069 | R-13.0 |
| Wood-Framed and Other | U-0.051 | R-19.0 | U-0.033 | R-30.0 | U-0.066 | R-13.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.730 | NR | F-0.730 | NR | F-0.730 | NR |
| Heated | F-0.900 | R-10 for 24 in. | F-0.900 | R-10 for 24 in. | F-1.020 | R-7.5 for 12 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.700 | | U-0.700 | | U-0.700 | |
| Nonswinging | U-1.450 | | U-0.500 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-0.65 | | U-0.65 | | U-1.20 | |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-0.60 | SHGC-0.25 all | U-0.60 | SHGC-0.25 all | U-1.20 | SHGC-NR all |
| Metal framing (entrance door)[~~e~~d] | U-0.90 | | U-0.90 | | U-1.20 | |
| Metal framing (all other)[~~e~~d] | U-0.65 | | U-0.65 | | U-1.20 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.39 | $U_{all}$–1.17 | $SHGC_{all}$–0.36 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.19 | $U_{all}$–1.17 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.30 | $SHGC_{all}$–0.65 | $U_{all}$–1.30 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.30 | $SHGC_{all}$–0.34 | $U_{all}$–1.30 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.39 | $U_{all}$–0.69 | $SHGC_{all}$–0.36 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.19 | $U_{all}$–0.69 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.

[~~a~~b]Exception to Section A3.1.3.1 applies.

[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[~~e~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-4 Building Envelope Requirements For Climate Zone 4 (A, B, C)*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.173 | R-5.0 c.i. |
| Metal Building[a] | ~~U-0.065~~ U-0.055 | ~~R-19.0~~ R-13.0 + R-13.0 | ~~U-0.065~~ U-0.055 | ~~R-19.0~~ R-13.0 + R-13.0 | U-0.097 | R-10.0 |
| Attic and Other | U-0.027 | R-38.0 | U-0.027 | R-38.0 | U-0.053 | R-19.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.104 | R-9.5 c.i. | U-0.090 | R-11.4 c.i. | U-0.580 | NR |
| Metal Building | ~~U-0.113~~ U-0.084 | ~~R-13.0~~ R-19.0 | ~~U-0.113~~ U-0.084 | ~~R-13.0~~ R-19.0 | ~~U-0.134~~ U-0.113 | ~~R-10.0~~ R-13.0 |
| Steel-Framed | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.124 | R-13.0 |
| Wood-Framed and Other | U-0.089 | R-13.0 | U-0.064 | R-13.0 + R-3.8 c.i. | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-1.140 | NR | C-0.119 | R-7.5 c.i. | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.087 | R-8.3 c.i. | U-0.074 | R-10.4 c.i. | U-0.137 | R-4.2 c.i. |
| Steel-Joist | U-0.038 | R-30.0 | U-0.038 | R-30.0 | U-0.069 | R-13.0 |
| Wood-Framed and Other | U-0.033 | R-30.0 | U-0.033 | R-30.0 | U-0.066 | R-13.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.730 | NR | F-0.540 | R-10 for 24 in. | F-0.730 | NR |
| Heated | F-0.860 | R-15 for 24 in. | F-0.860 | R-15 for 24in. | F-1.020 | R-7.5 for 12 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.700 | | U-0.700 | | U-0.700 | |
| Nonswinging | U-1.500 | | U-0.500 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-0.40 | SHGC-0.40 all | U-0.40 | SHGC-0.40 all | U-1.20 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-0.50 | | U-0.50 | | U-1.20 | |
| Metal framing (entrance door)[~~e~~d] | U-0.85 | | U-0.85 | | U-1.20 | |
| Metal framing (all other)[~~e~~d] | U-0.55 | | U-0.55 | | U-1.20 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.49 | $U_{all}$–0.98 | $SHGC_{all}$–0.36 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.39 | $U_{all}$–0.98 | $SHGC_{all}$–0.19 | $U_{all}$–1.98 | $SHGC_{all}$-NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.30 | $SHGC_{all}$–0.65 | $U_{all}$–1.30 | $SHGC_{all}$–0.62 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.30 | $SHGC_{all}$–0.34 | $U_{all}$-1.30 | $SHGC_{all}$–0.27 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.49 | $U_{all}$–0.58 | $SHGC_{all}$–0.36 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.39 | $U_{all}$–0.58 | $SHGC_{all}$–0.19 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[~~a~~b]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-5 Building Envelope Requirements For Climate Zone 5 (A, B, C)*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.119 | R-7.6 c.i. |
| Metal Building[a] | ~~U-0.065~~<br>U-0.055 | ~~R-19.0~~<br>R-13.0 + R-13.0 | ~~U-0.065~~<br>U-0.055 | ~~R-19.0~~<br>R-13.0 + R-13.0 | ~~U-0.097~~<br>U-0.083 | ~~R-10.0~~<br>R-13.0 |
| Attic and Other | U-0.027 | R-38.0 | U-0.027 | R-38.0 | U-0.053 | R-19.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.090 | R-11.4 c.i. | U-0.080 | R-13.3 c.i. | U-0.151[ab] | R-5.7 c.i.[ab] |
| Metal Building | ~~U-0.113~~<br>U-0.069 | ~~R-13.0~~<br>R-13.0 + R- 5.6 c.i. | ~~U-0.057~~<br>U-0.069 | ~~R-13.0 + R-13.0~~<br>R-13.0 + R- 5.6 c.i. | ~~U-0.123~~<br>U-0.113 | ~~R-11.0~~<br>R-13.0 |
| Steel-Framed | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.124 | R-13.0 |
| Wood-Framed and Other | U-0.064 | R-13.0 + R-3.8 c.i. | U-0.051 | R-13.0 + R-7.5 c.i. | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.119 | R-7.5 c.i. | C-0.119 | R-7.5 c.i. | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.074 | R-10.4 c.i. | U-0.064 | R-12.5 c.i. | U-0.137 | R-4.2 c.i. |
| Steel-Joist | U-0.038 | R-30.0 | U-0.038 | R-30.0 | U-0.052 | R-19.0 |
| Wood-Framed and Other | U-0.033 | R-30.0 | U-0.033 | R-30.0 | U-0.051 | R-19.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.730 | NR | F-0.540 | R-10 for 24 in. | F-0.730 | NR |
| Heated | F-0.860 | R-15 for 24 in. | F-0.860 | R-15 for 24 in. | F-1.020 | R-7.5 for 12 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.700 | | U-0.500 | | U-0.700 | |
| Nonswinging | U-0.500 | | U-0.500 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, % of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-0.35 | SHGC-0.40 all | U-0.35 | SHGC-0.40 all | U-1.20 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-0.45 | | U-0.45 | | U-1.20 | |
| Metal framing (entrance door)[~~e~~d] | U-0.80 | | U-0.80 | | U-1.20 | |
| Metal framing (all other)[~~e~~d] | U-0.55 | | U-0.55 | | U-1.20 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.49 | $U_{all}$–1.17 | $SHGC_{all}$–0.49 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.39 | $U_{all}$–1.17 | $SHGC_{all}$–0.39 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.10 | $SHGC_{all}$–0.77 | $U_{all}$–1.10 | $SHGC_{all}$–0.77 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.10 | $SHGC_{all}$–0.62 | $U_{all}$–1.10 | $SHGC_{all}$–0.62 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.49 | $U_{all}$–0.69 | $SHGC_{all}$–0.49 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.39 | $U_{all}$–0.69 | $SHGC_{all}$–0.39 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[ab]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~e~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-6 Building Envelope Requirements For Climate Zone 6 (A, B)*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.093 | R-10.0 c.i. |
| Metal Building[a] | ~~U-0.065~~ U-0.049 | ~~R-19.0~~ R-13.0 + R-19.0 | ~~U-0.065~~ U-0.049 | ~~R-19.0~~ R-13.0 + R-19.0 | ~~U-0.097~~ U-0.072 | ~~R-10.0~~ R-16.0 |
| Attic and Other | U-0.027 | R-38.0 | U-0.027 | R-38.0 | U-0.034 | R-30.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.080 | R-13.3 c.i. | U-0.071 | R-15.2 c.i. | U-0.151[a] | R-5.7 c.i.[a] |
| Metal Building | ~~U-0.113~~ U-0.069 | ~~R-13.0~~ R-13.0 + R-5.6 c.i. | ~~U-0.057~~ U-0.069 | ~~R-13.0 + R-13.0~~ R-13.0 + R-5.6 c.i. | U-0.113 | R-13.0 |
| Steel-Framed | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.124 | R-13.0 |
| Wood-Framed and Other | U-0.051 | R-13.0 + R-7.5 c.i. | U-0.051 | R-13.0 + R-7.5 c.i. | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.119 | R-7.5 c.i. | C-0.119 | R-7.5 c.i. | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.064 | R-12.5 c.i. | U-0.057 | R-14.6 c.i. | U-0.137 | R-4.2 c.i. |
| Steel-Joist | U-0.038 | R-30.0 | U-0.032 | R-38.0 | U-0.052 | R-19.0 |
| Wood-Framed and Other | U-0.033 | R-30.0 | U-0.033 | R-30.0 | U-.0051 | R-19.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.540 | R-10 for 24 in. | F-0.520 | R-15 for 24 in. | F-0.730 | NR |
| Heated | F-0.860 | R-15 for 24 in. | F-0.688 | R-20 for 48 in. | F-1.020 | R-7.5 for 12 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.700 | | U-0.500 | | U-0.700 | |
| Nonswinging | U-0.500 | | U-0.500 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-0.35 | SHGC-0.40 all | U-0.35 | SHGC-0.40 all | U-0.65 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-0.45 | | U-0.45 | | U-0.60 | |
| Metal framing (entrance door)[~~e~~d] | U-0.80 | | U-0.80 | | U-0.90 | |
| Metal framing (all other)[~~e~~d] | U-0.55 | | U-0.55 | | U-0.65 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.49 | $U_{all}$–0.98 | $SHGC_{all}$–0.46 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.49 | $U_{all}$–0.98 | $SHGC_{all}$–0.36 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.87 | $SHGC_{all}$–0.71 | $U_{all}$–0.74 | $SHGC_{all}$–0.65 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.87 | $SHGC_{all}$–0.58 | $U_{all}$–0.74 | $SHGC_{all}$–0.55 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.49 | $U_{all}$–0.58 | $SHGC_{all}$–0.49 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.49 | $U_{all}$–0.58 | $SHGC_{all}$–0.39 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.

[~~a~~b]Exception to Section A3.1.3.1 applies.

[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-7 Building Envelope Requirements For Climate Zone 7*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.093 | R-10.0 c.i. |
| Metal Building[a] | U-0.065<br>U-0.049 | R-19.0<br>R-13.0 + R-19.0 | U-0.065<br>U-0.049 | R-19.0<br>R-13.0 + R-19.0 | U-0.097<br>U-0.072 | R-10.0<br>R-16.0 |
| Attic and Other | U-0.027 | R-38.0 | U-0.027 | R-38.0 | U-0.034 | R-30.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.071 | R-15.2 c.i. | U-0.071 | R-15.2 c.i. | U-0.123 | R-7.6 c.i. |
| Metal Building | U-0.057 | ~~R-13.0 + R-13.0~~<br>R-19.0 + R-5.6 c.i. | U-0.057 | ~~R-13.0 + R-13.0~~<br>R-19.0 + R-5.6 c.i. | U-0.113 | R-13.0 |
| Steel-Framed | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.042 | R-13.0 + R-15.6 c.i. | U-0.124 | R-13.0 |
| Wood-Framed and Other | U-0.051 | R-13.0 + R-7.5 c.i. | U-0.051 | R-13.0 + R-7.5 c.i. | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.119 | R-7.5 c.i. | C-0.092 | R-10.0 c.i. | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.064 | R-12.5 c.i. | U-0.051 | R-16.7 c.i. | U-0.107 | R-6.3 c.i. |
| Steel-Joist | U-0.038 | R-30.0 | U-0.032 | R-38.0 | U-0.052 | R-19.0 |
| Wood-Framed and Other | U-0.033 | R-30.0 | U-0.033 | R-30.0 | U-0.051 | R-19.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.520 | R-15 for 24 in. | F-0.520 | R-15 for 24 in. | F-0.730 | NR |
| Heated | F-0.843 | R-20 for 24in. | F-0.688 | R-20 for 48 in. | F-0.900 | R-10 for 24 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.500 | | U-0.500 | | U-0.700 | |
| Nonswinging | U-0.500 | | U-0.500 | | U-1.450 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-0.35 | | U-0.35 | | U-0.65 | |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-0.40 | SHGC-0.45 all | U-0.40 | SHGC-NR all | U-0.60 | SHGC-NR all |
| Metal framing (entrance door)[~~e~~d] | U-0.80 | | U-0.80 | | U-0.90 | |
| Metal framing (all other)[~~e~~d] | U-0.45 | | U-0.45 | | U-0.65 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.68 | $U_{all}$–1.17 | $SHGC_{all}$–0.64 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–1.17 | $SHGC_{all}$–0.64 | $U_{all}$–1.17 | $SHGC_{all}$–0.64 | $U_{all}$–1.98 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.87 | $SHGC_{all}$–0.77 | $U_{all}$–0.61 | $SHGC_{all}$–0.77 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.87 | $SHGC_{all}$–0.71 | $U_{all}$–0.61 | $SHGC_{all}$–0.77 | $U_{all}$–1.90 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.68 | $U_{all}$–0.69 | $SHGC_{all}$–0.64 | $U_{all}$–1.36 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.69 | $SHGC_{all}$–0.64 | $U_{all}$–0.69 | $SHGC_{all}$–0.64 | $U_{all}$–1.36 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[~~a~~b]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-8 Building Envelope Requirements For Climate Zone 8*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.048 | R-20.0 c.i. | U-0.048 | R-20.0 c.i. | U-0.063 | R-15.0 c.i. |
| Metal Building[a] | ~~U-0.049~~<br>U-0.035 | ~~R-13.0 + R-19.0~~<br>R-11.0 + R-19.0 ls | ~~U-0.049~~<br>U-0.035 | ~~R-13.0 + R-19.0~~<br>R-11.0 + R-19.0 ls | ~~U-0.072~~<br>U-0.065 | ~~R-16.0~~<br>R-19.0 |
| Attic and Other | U-0.021 | R-49.0 | U-0.021 | R-49.0 | U-0.034 | R-30.0 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.071 | R-15.2 c.i. | U-0.052 | R-25.0 c.i. | U-0.104 | R-9.5 c.i. |
| Metal Building | U-0.057 | ~~R-13.0 + R-13.0~~<br>R-19.0 + R-5.6 c.i. | U-0.057 | ~~R-13.0 + R-13.0~~<br>R-19.0 + R-5.6 c.i. | U-0.113 | R-13.0 |
| Steel-Framed | U-0.064 | R-13.0 + R-7.5 c.i. | U-0.037 | R-13.0 + R-18.8 c.i. | U-0.084 | R-13.0 + R-3.8 c.i. |
| Wood-Framed and Other | U-0.036 | R-13.0 + R-15.6 c.i. | U-0.036 | R-13.0 + R-15.6 c.i. | U-0.089 | R-13.0 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.119 | R-7.5 c.i. | C-0.075 | R-12.5 c.i. | C-1.140 | NR |
| *Floors* | | | | | | |
| Mass | U-0.057 | R-14.6 c.i. | U-0.051 | R-16.7 c.i. | U-0.087 | R-8.3 c.i. |
| Steel-Joist | U-0.032 | R-38.0 | U-0.032 | R-38.0 | U-0.052 | R-19.0 |
| Wood-Framed and Other | U-0.033 | R-30.0 | U-0.033 | R-30.0 | U-0.033 | R-30.0 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.520 | R-15 for 24 in. | F-0.510 | R-20 for 24 in. | F-0.730 | NR |
| Heated | F-0.688 | R-20 for 48 in. | F-0.688 | R-20 for 48 in. | F-0.900 | R-10.0 for 24 in. |
| *Opaque Doors* | | | | | | |
| Swinging | U-0.500 | | U-0.500 | | U-0.700 | |
| Nonswinging | U-0.500 | | U-0.500 | | U-0.500 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[~~b~~c] | U-0.35 | | U-0.35 | | U-0.65 | |
| Metal framing (curtainwall/storefront)[~~e~~d] | U-0.40 | SHGC-0.45 all | U-0.40 | SHGC-NR all | U-0.60 | SHGC-NR all |
| Metal framing (entrance door)[~~e~~d] | U-0.80 | | U-0.80 | | U-0.90 | |
| Metal framing (all other)[~~e~~d] | U-0.45 | | U-0.45 | | U-0.65 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.98 | $SHGC_{all}$–NR | $U_{all}$–0.98 | $SHGC_{all}$–NR | $U_{all}$–1.30 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.98 | $SHGC_{all}$–NR | $U_{all}$–0.98 | $SHGC_{all}$–NR | $U_{all}$–1.30 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.61 | $SHGC_{all}$–NR | $U_{all}$–0.61 | $SHGC_{all}$–NR | $U_{all}$–1.10 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.61 | $SHGC_{all}$–NR | $U_{all}$–0.61 | $SHGC_{all}$–NR | $U_{all}$–1.10 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–0.58 | $SHGC_{all}$–NR | $U_{all}$–0.58 | $SHGC_{all}$–NR | $U_{all}$–0.81 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–0.58 | $SHGC_{all}$–NR | $U_{all}$–0.58 | $SHGC_{all}$–NR | $U_{all}$–0.81 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.

[~~a~~b]Exception to Section A3.1.3.1 applies.

[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[~~e~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

*Modify Section 5 as follows (SI units):*

**TABLE 5.5-1 Building Envelope Requirements for Climate Zone 1 (A, B)***

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.360 | R-2.6 c.i. | U-0.273 | R-3.5 c.i. | U-1.240 | R-0.7 ci |
| Metal Building[a] | U-0.369 | R-3.3 | U-0.369 | R-3.3 | ~~U-7.268~~<br>U-0.947 | ~~NR~~<br>R-1.1 |
| Attic and Other | U-0.192 | R-5.3 | U-0.153 | R-6.7 | U-0.459 | R-2.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-3.293 | NR | U-0.857[ab] | R-1.0 c.i.[ab] | U-3.293 | NR |
| Metal Building | ~~U-0.642~~<br>U-0.527 | ~~R-2.3~~<br>R-2.8 | ~~U-0.642~~<br>U-0.527 | ~~R-2.3~~<br>R-2.8 | ~~U-6.700~~<br>U-0.642 | ~~NR~~<br>R-2.3 |
| Steel-Framed | U-0.705 | R-2.3 | U-0.705 | R-2.3 | U-1.998 | NR |
| Wood-Framed and Other | U-0.504 | R-2.3 | U-0.504 | R-2.3 | U-1.660 | NR |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-6.473 | NR | C-6.473 | NR | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-1.825 | NR | U-1.825 | NR | U-1.825 | NR |
| Steel-Joist | U-1.986 | NR | U-1.986 | NR | U-1.986 | NR |
| Wood-Framed and Other | U-1.599 | NR | U-1.599 | NR | U-1.599 | NR |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-1.264 | NR | F-1.264 | NR | F-1.264 | NR |
| Heated | U-1.766 | R-1.3 for 300 mm | F-1.766 | R-1.3 for 300 mm | F-1.766 | R-1.3 for 300 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-3.975 | | U-3.975 | | U-3.975 | |
| Nonswinging | U-8.233 | | U-8.233 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-6.81 | SHGC-0.25 all | U-6.81 | SHGC-0.25 all | U-6.81 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[c] | U-6.81 | | U-6.81 | | U-6.81 | |
| Metal framing (entrance door)[c] | U-6.81 | | U-6.81 | | U-6.81 | |
| Metal framing (all other)[c] | U-6.81 | | U-6.81 | | U-6.81 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–11.24 | $SHGC_{all}$–0.36 | $U_{all}$–11.24 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–11.24 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$–0.16 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–10.79 | $SHGC_{all}$–0.34 | $U_{all}$–10.79 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–10.79 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–7.72 | $SHGC_{all}$–0.36 | $U_{all}$–7.72 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–7.72 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
[ab]Exception to Section A3.1.3.1 applies.
[bc]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[cd]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-2 Building Envelope Requirements for Climate Zone 2 (A, B)*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-1.240 | R-0.7 c.i. |
| Metal Building[a] | ~~U-0.369~~<br>U-0.312 | ~~R-3.3~~<br>R-2.3 + R-2.3 | ~~U-0.369~~<br>U-0.312 | ~~R-3.3~~<br>R-2.3 + R-2.3 | ~~U-0.948~~<br>U-0.551 | ~~R-1.1~~<br>R-1.8 |
| Attic and Other | U-0.153 | R-6.7 | U-0.153 | R-6.7 | U-0.459 | R-2.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.857[a] | R-1.0 c.i.[a] | U-0.701[b] | R-1.3 c.i.[b] | U-3.293 | NR |
| Metal Building | ~~U-0.642~~<br>U-0.528 | ~~R-2.3~~<br>R-2.8 | ~~U-0.642~~<br>U-0.528 | ~~R-2.3~~<br>R-2.8 | U-0.642 | R-2.3 |
| Steel-Framed | U-0.705 | R-2.3 | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.705 | R-2.3 |
| Wood-Framed and Other | U-0.504 | R-2.3 | U-0.504 | R-2.3 | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-6.473 | NR | C-6.473 | NR | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.606 | R-1.1 c.i. | U-0.496 | R-1.5 c.i. | U-1.825 | NR |
| Steel-Joist | U-0.296 | R-3.3 | U-0.296 | R-3.3 | U-0.390 | R-2.3 |
| Wood-Framed and Other | U-0.288 | R-3.3 | U-0.188 | R-5.3 | U-0.376 | R-2.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-1.264 | NR | F-1.264 | NR | F-1.264 | NR |
| Heated | F-1.766 | R-1.3 for 300 mm | F-1.766 | R-1.3 for 300 mm | F-1.766 | R-1.3 for 300 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-3.975 | | U-3.975 | | U-3.975 | |
| Nonswinging | U-8.233 | | U-2.839 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-4.26 | SHGC-0.25 all | U-4.26 | SHGC-0.25 all | U-6.81 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[c] | U-3.97 | | U-3.97 | | U-6.81 | |
| Metal framing (entrance door)[c] | U-6.25 | | U-6.25 | | U-6.81 | |
| Metal framing (all other)[c] | U-4.26 | | U-4.26 | | U-6.81 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–11.24 | $SHGC_{all}$–0.36 | $U_{all}$–11.24 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–11.24 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–10.79 | $SHGC_{all}$–0.39 | $U_{all}$–10.79 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–10.79 | $SHGC_{all}$–0.34 | $U_{all}$–10.79 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–7.72 | $SHGC_{all}$–0.36 | $U_{all}$–7.72 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–7.72 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
~~[ab]~~Exception to Section A3.1.3.1 applies.
~~[bc]~~Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
~~[cd]~~Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

**TABLE 5.5-3 Building Envelope Requirements for Climate Zone 3 (A, B, C)***

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-0.982 | R-0.9 c.i. |
| Metal Building[a] | ~~U-0.369~~ U-0.312 | ~~R-3.3~~ R-2.3 + R-2.3 | ~~U-0.369~~ U-0.312 | ~~R-3.3~~ R-2.3 + R-2.3 | U-0.551 | R-1.8 |
| Attic and Other | U-0.153 | R-6.7 | U-0.153 | R-6.7 | U-0.300 | R-3.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.701 | R-1.3 c.i. | U-0.592 | R-1.7 c.i. | U-3.293 | NR |
| Metal Building | ~~U-0.642~~ U-0.477 | ~~R-2.3~~ R-3.3 | ~~U-0.642~~ U-0.476 | ~~R-2.3~~ R-3.3 | ~~U-1.045~~ U-0.642 | ~~R-1.1~~ R-2.3 |
| Steel-Framed | U-0.479 | R-2.3 + R-0.7 c.i. | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.705 | R-2.3 |
| Wood-Framed and Other | U-0.504 | R-2.3 | U-0.504 | R-2.3 | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-6.473 | NR | C-6.473 | NR | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.606 | R-1.1 | U-0.496 | R-1.5 | U-1.825 | NR |
| Steel-Joist | U-0.296 | R-3.3 | U-0.296 | R-3.3 | U-0.390 | R-2.3 |
| Wood-Framed and Other | U-0.288 | R-3.3 | U-0.188 | R-5.3 | U-0.376 | R-2.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-1.264 | NR | F-1.264 | NR | F-1.264 | NR |
| Heated | F-1.558 | R-1.8 for 600 mm | F-1.558 | R-1.8 for 600 mm | F-1.766 | R-1.3 for 300 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-3.975 | | U-3.975 | | U-3.975 | |
| Nonswinging | U-8.233 | | U-2.839 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-3.69 | | U-3.69 | | U-6.81 | |
| Metal framing (curtainwall/storefront)[c] | U-3.41 | SHGC-0.25 all | U-3.41 | SHGC-0.25 all | U-6.81 | SHGC-NR all |
| Metal framing (entrance door)[c] | U-5.11 | | U-5.11 | | U-6.81 | |
| Metal framing (all other)[c] | U-3.69 | | U-3.69 | | U-6.81 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.39 | $U_{all}$–6.64 | $SHGC_{all}$–0.36 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.19 | $U_{all}$–6.64 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–7.38 | $SHGC_{all}$–0.65 | $U_{all}$–7.38 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–7.38 | $SHGC_{all}$–0.34 | $U_{all}$–7.38 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.39 | $U_{all}$–3.92 | $SHGC_{all}$–0.36 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.19 | $U_{all}$–3.92 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.

[~~a~~b]Exception to A3.1.3.1 applies.

[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

**TABLE 5.5-4 Building Envelope Requirements for Climate Zone 4 (A, B, C)***

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-0.982 | R-0.9 c.i. |
| Metal Building[a] | U-0.369<br>U-0.312 | ~~R-3.3~~<br>R-2.3 + R-2.3 | ~~U-0.369~~<br>U-0.312 | ~~R-3.3~~<br>R-2.3 + R-2.3 | U-0.551 | R-1.8 |
| Attic and Other | U-0.0.153 | R-6.7 | U-0.153 | R-6.7 | U-0.300 | R-3.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.592 | R-1.7 c.i. | U-0.513 | R-2.0 c.i. | U-3.293 | NR |
| Metal Building | ~~U-0.642~~<br>U-0.477 | ~~R-2.3~~<br>R-3.3 | ~~U-0.642~~<br>U-0.476 | ~~R-2.3~~<br>R-3.3 | U-0.642 | R-2.3 |
| Steel-Framed | U-0.365 | R-2.3 + R-1.3 | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.705 | R-2.3 |
| Wood-Framed and Other | U-0.504 | R-2.3 | U-0.365 | R-2.3 + R-0.7 c.i. | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-6.473 | NR | C-0.678 | R-1.3 c.i. | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.496 | R-1.5 c.i. | U-0.420 | R-1.8 c.i. | U-0.780 | R-0.7 c.i. |
| Steel-Joist | U-0.214 | R-5.3 | U-0.214 | R-5.3 | U-0.390 | R-2.3 |
| Wood-Framed and Other | U-0.188 | R-5.3 | U-0.188 | R-5.3 | U-0.376 | R-2.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-1.264 | NR | F-0.935 | R-1.8 for 600 mm | F-1.264 | NR |
| Heated | F-1.489 | R-2.6 for 600 mm | F-1.489 | R-2.6 for 600 mm | F-1.766 | R-1.3 for 300 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-3.975 | | U-3.975 | | U-3.975 | |
| Nonswinging | U-2.839 | | U-2.839 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-2.27 | | U-2.27 | | U-6.81 | |
| Metal framing (curtainwall/storefront)[c] | U-2.84 | SHGC-0.40 all | U-2.84 | SHGC-0.40 all | U-6.81 | SHGC-NR all |
| Metal framing (entrance door)[c] | U-4.83 | | U-4.83 | | U-6.81 | |
| Metal framing (all other)[c] | U-3.12 | | U-3.12 | | U-6.81 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.49 | $U_{all}$–5.56 | $SHGC_{all}$–0.36 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.39 | $U_{all}$–5.56 | $SHGC_{all}$–0.19 | $U_{all}$–11.24 | $SHGC_{all}$-NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–7.38 | $SHGC_{all}$–0.65 | $U_{all}$–7.38 | $SHGC_{all}$–0.62 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–7.38 | $SHGC_{all}$–0.34 | $U_{all}$–7.38 | $SHGC_{all}$–0.27 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.49 | $U_{all}$–3.29 | $SHGC_{all}$–0.36 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.39 | $U_{all}$–3.29 | $SHGC_{all}$–0.19 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
[~~a~~b]Exception to A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

**TABLE 5.5-5 Building Envelope Requirements for Climate Zone 5 (A, B, C)***

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-0.677 | R-1.3 c.i. |
| Metal Building[a] | ~~U-0.369~~<br>U-0.312 | ~~R-3.3~~<br>R-2.3 +R-2.3 | ~~U-0.369~~<br>U-0.312 | ~~R-3.3~~<br>R-2.3 + R-2.3 | ~~U-0.551~~<br>U-0.471 | ~~R-1.8~~<br>R-2.3 |
| Attic and Other | U-0.153 | R-6.7 | U-0.153 | R-6.7 | U-0.300 | R-3.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.513 | R-2.0 c.i. | U-0.453 | R-2.3 c.i. | U-0.857[a] | R-1.0 c.i.[a] |
| Metal Building | ~~U-0.642~~<br>U-0.391 | ~~R-2.3~~<br>R-2.3 + R-1.0 c.i. | ~~U-0.324~~<br>U-0.391 | ~~R-2.3 + R-2.3~~<br>R-2.3 + R-1.0 c.i. | ~~U-0.698~~<br>U-0.642 | ~~R-1.9~~<br>R-2.3 |
| Steel-Framed | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.365 | R-2.3 +R-1.3 c.i. | U-0.705 | R-2.3 |
| Wood-Framed and Other | U-0.365 | R-2.3 + R-0.7 c.i. | U-0.291 | R-2.3 + R-1.3 c.i. | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.678 | R-1.3 c.i. | C-0.678 | R-1.3 c.i. | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.420 | R-1.8 c.i. | U-0.363 | R-2.2 c.i. | U-0.780 | R-0.7 c.i. |
| Steel-Joist | U-0.214 | R-5.3 | U-0.214 | R-5.3 | U-0.296 | R-3.3 |
| Wood-Framed and Other | U-0.188 | R-5.3 | U-0.188 | R-5.3 | U-0.288 | R-3.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-1.264 | NR | F-0.935 | R-1.8 for 600 mm | F-1.264 | NR |
| Heated | F-1.489 | R-2.6 for 600 mm | F-1.489 | R-2.6 for 600 mm | F-1.766 | R-1.3 for 300 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-3.975 | | U-2.839 | | U-3.975 | |
| Nonswinging | U-2.839 | | U-2.839 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, % of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-1.99 | SHGC-0.40 all | U-1.99 | SHGC-0.40 all | U-6.81 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[c] | U-2.56 | | U-2.56 | | U-6.81 | |
| Metal framing (entrance door)[c] | U-4.54 | | U-4.54 | | U-6.81 | |
| Metal framing (all other)[c] | U-3.12 | | U-3.12 | | U-6.81 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.49 | $U_{all}$–6.64 | $SHGC_{all}$–0.49 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.39 | $U_{all}$–6.64 | $SHGC_{all}$–0.39 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–6.25 | $SHGC_{all}$–0.77 | $U_{all}$–6.25 | $SHGC_{all}$–0.77 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–6.25 | $SHGC_{all}$–0.62 | $U_{all}$–6.25 | $SHGC_{all}$–0.62 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.49 | $U_{all}$–3.92 | $SHGC_{all}$–0.49 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.39 | $U_{all}$–3.92 | $SHGC_{all}$–0.39 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
~~[a]~~[b]Exception to Section A3.1.3.1 applies.
~~[b]~~[c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
~~[c]~~[d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-6 Building Envelope Requirements for Climate Zone 6 (A, B)*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-0.527 | R-1.8 c.i. |
| Metal Building[a] | ~~U-0.369~~ U-0.278 | ~~R-3.3~~ R-2.3 + R-3.3 | ~~U-0.369~~ U-0.278 | ~~R-3.3~~ R-2.3 + R-3.3 | ~~U-0.551~~ U-0.409 | ~~R-1.8~~ R-2.8 |
| Attic and Other | U-0.153 | R-6.7 | U-0.153 | R-6.7 | U-0.192 | R-5.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.453 | R-2.3 c.i. | U-0.404 | R-2.7 c.i. | U-0.857[a] | R-1.0 c.i.[a] |
| Metal Building | ~~U-0.642~~ U-0.392 | ~~R-2.3~~ R-2.3 + R-1.0 c.i. | ~~U-0.324~~ U-0.392 | ~~R-2.3 + R-2.3~~ R-2.3 + R-1.0 c.i. | U-0.642 | R-2.3 |
| Steel-Framed | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.705 | R-2.3 |
| Wood-Framed and Other | U-0.291 | R-2.3 + R-1.3 c.i. | U-0.291 | R-2.3 + R-1.3 c.i. | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.678 | R-1.3 c.i. | C-0.678 | R-1.3c.i. | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.363 | R-2.2 c.i. | U-0.321 | R-2.6 c.i. | U-0.780 | R-0.7 c.i. |
| Steel-Joist | U-0.214 | R-5.3 | U-0.183 | R-6.7 | U-0.296 | R-3.3 |
| Wood-Framed and Other | U-0.188 | R-5.3 | U-0.188 | R-5.3 | U-0.288 | R-3.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.935 | R-1.8 for 600 mm | F-0.900 | R-2.6 for 600 mm | F-1.264 | NR |
| Heated | F-1.489 | R-2.6 for 600 mm | F-1.191 | R-3.5 for 1200 mm | F-1.766 | R-1.3 for 300 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-3.975 | | U-2.839 | | U-3.975 | |
| Nonswinging | U-2.839 | | U-2.839 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-1.99 | SHGC-0.40 all | U-1.99 | SHGC-0.40 all | U-3.69 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[c] | U-2.56 | | U-2.56 | | U-3.41 | |
| Metal framing (entrance door)[c] | U-4.54 | | U-4.54 | | U-5.11 | |
| Metal framing (all other)[c] | U-3.12 | | U-3.12 | | U-3.69 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.49 | $U_{all}$–5.56 | $SHGC_{all}$–0.46 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.49 | $U_{all}$–5.56 | $SHGC_{all}$–0.36 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–4.94 | $SHGC_{all}$–0.71 | $U_{all}$–4.20 | $SHGC_{all}$–0.65 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–4.94 | $SHGC_{all}$–0.58 | $U_{all}$–4.20 | $SHGC_{all}$–0.55 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.49 | $U_{all}$–3.29 | $SHGC_{all}$–0.49 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.49 | $U_{all}$–3.29 | $SHGC_{all}$–0.39 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
[~~a~~b]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-7 Building Envelope Requirements for Climate Zone 7*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-0.527 | R-1.8 c.i. |
| Metal Building[a] | ~~U-0.369~~<br>U-0.278 | ~~R-3.3~~<br>R-2.3 + R-3.3 | ~~U-0.369~~<br>U-0.278 | ~~R-3.3~~<br>R-2.3 + R-3.3 | ~~U-0.551~~<br>U-0.409 | ~~R-1.8~~<br>R-2.8 |
| Attic and Other | U-0.153 | R-6.7 | U-0.153 | R-6.7 | U-0.192 | R-5.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.404 | R-2.7 c.i. | U-0.404 | R-2.7 c.i. | U-0.701 | R-1.3 c.i. |
| Metal Building | U-0.324 | ~~R-2.3 + R-2.3~~<br>R-3.3 + R-1.0 c.i. | U-0.324 | ~~R-2.3 + R-2.3~~<br>R-3.3 + R-1.0 c.i. | U-0.642 | R-2.3 |
| Steel-Framed | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.240 | R-2.3 + R-2.7 c.i. | U-0.705 | R-2.3 |
| Wood-Framed and Other | U-0.291 | R-2.3 + R-1.3 c.i. | U-0.291 | R-2.3 +R-1.3 c.i. | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.678 | R-1.3 c.i. | C-0.522 | R-1.8 c.i. | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.363 | R-2.2 c.i. | U-0.287 | R-2.9 c.i. | U-0.606 | R-1.1 c.i. |
| Steel-Joist | U-0.214 | R-5.3 | U-0.183 | R-6.7 | U-0.296 | R-3.3 |
| Wood-Framed and Other | U-0.188 | R-5.3 | U-0.188 | R-5.3 | U-0.288 | R-3.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.900 | R-2.6 for 600 mm | F-0.900 | R-2.6 for 600 mm | F-1.264 | NR |
| Heated | F-1.459 | R-3.5 for 600 mm | F-1.191 | R-3.5 for 1200 | F-1.558 | R-1.8 for 600 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-2.839 | | U-2.839 | | U-3.975 | |
| Nonswinging | U-2.839 | | U-2.839 | | U-8.233 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-1.99 | | U-1.99 | | U-3.69 | |
| Metal framing (curtainwall/storefront)[c] | U-2.27 | SHGC-0.45 all | U-2.27 | SHGC-NR all | U-3.41 | SHGC-NR all |
| Metal framing (entrance door)[c] | U-4.54 | | U-4.54 | | U-5.11 | |
| Metal framing (all other)[c] | U-2.56 | | U-2.56 | | U-3.69 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.68 | $U_{all}$–6.64 | $SHGC_{all}$–0.64 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–6.64 | $SHGC_{all}$–0.64 | $U_{all}$–6.64 | $SHGC_{all}$–0.64 | $U_{all}$–11.24 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–4.94 | $SHGC_{all}$–0.77 | $U_{all}$–3.46 | $SHGC_{all}$–0.77 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–4.94 | $SHGC_{all}$–0.71 | $U_{all}$–3.46 | $SHGC_{all}$–0.77 | $U_{all}$–10.79 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.68 | $U_{all}$–3.92 | $SHGC_{all}$–0.64 | $U_{all}$–7.72 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.92 | $SHGC_{all}$–0.64 | $U_{all}$–3.92 | $SHGC_{all}$–0.64 | $U_{all}$–7.72 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
[~~b~~b]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

## TABLE 5.5-8 Building Envelope Requirements for Climate Zone 8*

| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Roofs* | | | | | | |
| Insulation Entirely above Deck | U-0.273 | R-3.5 c.i. | U-0.273 | R-3.5 c.i. | U-0.360 | R-2.6 c.i. |
| Metal Building[a] | ~~U-0.278~~ U-0.199 | ~~R-2.3 + R-3.3~~ R-1.9 + R-3.3 ls | ~~U-0.278~~ U-0.199 | ~~R-2.3 + R-3.3~~ R-1.9 +R-3.3 ls | ~~U-0.409~~ U-0.369 | ~~R-2.8~~ R-3.3 |
| Attic and Other | U-0.119 | R-8.6 | U-0.119 | R-8.6 | U-0.192 | R-5.3 |
| *Walls, Above-Grade* | | | | | | |
| Mass | U-0.404 | R-2.7 c.i. | U-0.295 | R-4.4 c.i. | U-0.592 | R-1.7 c.i. |
| Metal Building | U-0.324 | ~~R-2.3 + R-2.3~~ R-3.3 +R-1.0 c.i. | U-0.324 | ~~R-2.3 + R-2.3~~ R-3.3 +R-1.0 c.i. | U-0.642 | R-2.3 |
| Steel-Framed | U-0.365 | R-2.3 + R-1.3 c.i. | U-0.212 | R-2.3 + R-3.3 c.i. | U-0.479 | R-2.3 + R-0.7 c.i. |
| Wood-Framed and Other | U-0.203 | R-2.3 +R-2.7 c.i. | U-0.203 | R-2.3 + R-2.7 c.ic. | U-0.504 | R-2.3 |
| *Walls, Below-Grade* | | | | | | |
| Below-Grade Wall | C-0.678 | R-1.3 c.i. | C-0.425 | R-2.2 c.i. | C-6.473 | NR |
| *Floors* | | | | | | |
| Mass | U-0.321 | R-2.6 c.i. | U-0.287 | R-2.9 c.i. | U-0.496 | R-1.5 c.i. |
| Steel-Joist | U-0.183 | R-6.7 | U-0.183 | R-6.7 | U-0.296 | R-3.3 |
| Wood-Framed and Other | U-0.188 | R-5.3 | U-0.188 | R-5.3 | U-0.188 | R-5.3 |
| *Slab-On-Grade Floors* | | | | | | |
| Unheated | F-0.900 | R-2.6 for 600 mm | F-0.883 | R-3.5 for 600 mm | F-1.264 | NR |
| Heated | F-1.191 | R-3.5 for 1200 mm | F-1.191 | R-3.5 for 1200 mm | F-1.558 | R-1.8 for 600 mm |
| *Opaque Doors* | | | | | | |
| Swinging | U-2.839 | | U-2.839 | | U-3.975 | |
| Nonswinging | U-2.839 | | U-2.839 | | U-2.839 | |
| **Fenestration** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** | **Assembly Max. U** | **Assembly Max. SHGC** |
| *Vertical Glazing, 0%–40% of Wall* | | | | | | |
| Nonmetal framing (all)[b] | U-1.99 | SHGC-0.45 all | U-1.99 | SHGC-NR all | U-3.69 | SHGC-NR all |
| Metal framing (curtainwall/storefront)[c] | U-2.27 | | U-2.27 | | U-3.41 | |
| Metal framing (entrance door)[c] | U-4.54 | | U-4.54 | | U-5.11 | |
| Metal framing (all other)[c] | U-2.56 | | U-2.56 | | U-3.69 | |
| *Skylight with Curb, Glass, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–5.56 | $SHGC_{all}$–NR | $U_{all}$–5.56 | $SHGC_{all}$–NR | $U_{all}$–7.38 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–5.56 | $SHGC_{all}$–NR | $U_{all}$–5.56 | $SHGC_{all}$–NR | $U_{all}$–7.38 | $SHGC_{all}$–NR |
| *Skylight with Curb, Plastic, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.46 | $SHGC_{all}$–NR | $U_{all}$–3.46 | $SHGC_{all}$–NR | $U_{all}$–6.25 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.46 | $SHGC_{all}$–NR | $U_{all}$–3.46 | $SHGC_{all}$–NR | $U_{all}$–6.25 | $SHGC_{all}$–NR |
| *Skylight without Curb, All, % of Roof* | | | | | | |
| 0%–2.0% | $U_{all}$–3.29 | $SHGC_{all}$–NR | $U_{all}$–3.29 | $SHGC_{all}$–NR | $U_{all}$–4.60 | $SHGC_{all}$–NR |
| 2.1%–5.0% | $U_{all}$–3.29 | $SHGC_{all}$–NR | $U_{all}$–3.29 | $SHGC_{all}$–NR | $U_{all}$–4.60 | $SHGC_{all}$–NR |

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. See Table A2.3.
[~~a~~b]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

*Modify Appendix A as follows (I-P units):*

**A2.3 Metal Building Roofs**

**A2.3.1 General.** For the purpose of A1.2, the base assembly is a *roof* with *thermal spacer blocks* where the insulation is draped over the steel structure (purlins), spaced nominally 5 ft on center and ~~then~~ compressed when the metal roof panels are attached to the steel structure (purlins). ~~Additional assemblies include *continuous insulation*, uncompressed and uninterrupted by framing.~~

**A2.3.2 Rated R-Value of insulation**

**A2.3.2.1** The first *rated R-value of insulation* is for insulation draped over purlins and then compressed when the metal roof panels are attached, or for insulation hung between the purlins. A minimum R-3.5~~1 in.~~ thermal spacer block between the purlins and the metal roof panels is required when specified in Table A2.3.

**A2.3.2.2** For double-layer installations, the second *rated R-value of insulation* is for insulation installed parallel to the purlins.

**A2.3.2.3** For continuous insulation (e.g., insulation boards or blankets), it is assumed that the insulation is installed below the purlins and is uninterrupted by framing members. Insulation exposed to the *conditioned space* or *semiheated space* shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

**A2.3.2.4 *Liner System* (Ls).** A continuous vapor barrier liner is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the liner between the purlins. For multilayer installations, the *first rated R-Value of insulation* is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3.5 thermal spacer block between the purlins and the metal roof panels is required when specified in Table A2.3.

**A2.3.3 U-Factor.** *U-factors* for *metal building roofs* shall be taken from Table A2.3 It is not acceptable to use these *U-factors* if additional insulated sheathing is not continuous.

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**Exception to A3.1.3.1:**For *mass walls*, where the requirement in Tables 5.5-1 through 5.5-8 is for a maximum assembly U-0.151 followed by footnote "~~a~~b," …

*The remainder of Appendix A is unchanged.*

*Modify Tables A2.3 and A3.2 as follows (I-P units):*

**TABLE A2.3 Assembly U-Factors for Metal Building Roofs**

| Insulation System | Rated R-Value of Insulation | Total Rated R-Value of Insulation | Overall U-Factor for Entire Base Roof Assembly | Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (Uninterrupted by Framing) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Rated R-Value of Continuous Insulation | | | | | |
| | | | | R-5.6 | R-11.2 | R-16.8 | R-22.4 | R-28.0 | R-33.6 |
| **Standing Seam Roofs with Thermal Spacer Blocks** | | | | | | | | | |
| Single Layer | None | 0 | **U-1.280** | ~~0.162~~ 0.157 | ~~0.087~~ 0.083 | ~~0.059~~ 0.057 | ~~0.045~~ 0.043 | ~~0.036~~ 0.035 | ~~0.030~~ 0.029 |
| | R-6 | 6 | **U-0.167** | 0.086 | 0.058 | 0.044 | 0.035 | 0.029 | 0.025 |
| | R-10 | 10 | **U-0.097** | 0.063 | 0.046 | 0.037 | 0.031 | 0.026 | 0.023 |
| | R-11 | 11 | **U-0.092** | 0.061 | 0.045 | 0.036 | 0.030 | 0.026 | 0.022 |
| | R-13 | 13 | **U-0.083** | 0.057 | 0.043 | 0.035 | 0.029 | 0.025 | 0.022 |
| | R-16 | 16 | **U-0.072** | 0.051 | 0.040 | 0.033 | 0.028 | 0.024 | 0.021 |
| | R-19 | 19 | **U-0.065** | 0.048 | 0.038 | 0.031 | 0.026 | 0.023 | 0.020 |
| Double Layer | R-10 + R-10 | 20 | **U-0.063** | 0.047 | 0.037 | 0.031 | 0.026 | 0.023 | 0.020 |
| | R-10 + R-11 | 21 | **U-0.061** | 0.045 | 0.036 | 0.030 | 0.026 | 0.023 | 0.020 |
| | R-11 + R-11 | 22 | **U-0.060** | 0.045 | 0.036 | 0.030 | 0.026 | 0.022 | 0.020 |
| | R-10 + R-13 | 23 | **U-0.058** | 0.044 | 0.035 | 0.029 | 0.025 | 0.022 | 0.020 |
| | R-11 + R-13 | 24 | **U-0.057** | 0.043 | 0.035 | 0.029 | 0.025 | 0.022 | 0.020 |
| | R-13 + R-13 | 26 | **U-0.055** | 0.042 | 0.034 | 0.029 | 0.025 | 0.022 | 0.019 |
| | R-10 + R-19 | 29 | **U-0.052** | 0.040 | 0.033 | 0.028 | 0.024 | 0.021 | 0.019 |
| | R-11 + R-19 | 30 | **U-0.051** | 0.040 | 0.032 | 0.027 | 0.024 | 0.021 | 0.019 |
| | R-13 + R-19 | 32 | **U-0.049** | 0.038 | 0.032 | 0.027 | 0.023 | 0.021 | 0.019 |
| | R-16 + R-19 | 35 | **U-0.047** | 0.037 | 0.031 | 0.026 | 0.023 | 0.020 | 0.018 |
| | R-19 + R-19 | 38 | **U-0.046** | 0.037 | 0.030 | 0.026 | 0.023 | 0.020 | 0.018 |
| Liner System | R-11 + R-19 | 30 | **U-0.035** | | | | | | |
| | R-11 + R-25 | 36 | **U-0.031** | | | | | | |
| | R-11 + R-30 | 41 | **U-0.029** | | | | | | |
| | R-11 + R-11 + R-25 | 47 | **U-0.026** | | | | | | |
| **Standing Seam Roofs without Thermal Spacer Blocks** | | | | | | | | | |
| Liner System | R-11 + R-19 | 30 | **U-0.040** | | 0.028 | 0.024 | 0.021 | 0.020 | 0.017 |
| **Filled Cavity with Thermal Spacer Blocks** | | | | | | | | | |
| | R-19 + R-10 | 29 | **U-0.041** | 0.033 | 0.028 | 0.024 | 0.021 | ~~0.020~~0.019 | 0.017 |
| (Multiple R-values are listed in order from inside to outside.) | | | | | | | | | |
| **Thru-Fastened without Thermal Spacer Blocks** | | | | | | | | | |
| | R-10 | 10 | **U-0.153** | | | | | | |
| | R-11 | 11 | **U-0.139** | | | | | | |
| | R-13 | 13 | **U-0.130** | | | | | | |
| | R-16 | 16 | **U-0.106** | | | | | | |
| | R-19 | 19 | **U-0.098** | | | | | | |
| Liner System | R-11 + R-19 | 30 | **U-0.044** | | | | | | |

**TABLE A3.2 Assembly U-Factors for Metal Building Walls**

| Insulation System | Rated R-Value of Insulation | Total Rated R-Value of Insulation | Overall U-Factor for Entire Base Wall Assembly | Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Rated R-Value of Continuous Insulation | | | | | |
| | | | | R-5.6 | R-11.2 | R-16.8 | R-22.4 | R-28.0 | R-33.6 |
| **Single Layer of Mineral Fiber** | | | | | | | | | |
| | None | 0 | 1.180 | 0.161 | 0.086 | 0.059 | 0.045 | 0.036 | 0.030 |
| | R-6 | 6 | 0.184 | 0.091 | 0.060 | 0.045 | 0.036 | 0.030 | 0.026 |
| | R-10 | 10 | 0.134 | 0.077 | 0.054 | 0.051 | 0.033 | 0.028 | 0.024 |
| | R-11 | 11 | 0.123 | 0.073 | 0.052 | 0.040 | 0.033 | 0.028 | 0.024 |
| | R-13 | 13 | 0.113 | 0.069 | 0.050 | 0.039 | 0.032 | 0.027 | 0.024 |
| | R-16 | 16 | 0.093 | 0.061 | 0.046 | 0.036 | 0.030 | 0.026 | 0.023 |
| | R-19 | 19 | 0.084 | 0.057 | 0.043 | 0.035 | 0.029 | 0.025 | 0.022 |
| **Double Layer of Mineral Fiber** | | | | | | | | | |
| (Second layer inside of girts) | | | | | | | | | |
| (Multiple layers are listed in order from inside to outside) | | | | | | | | | |
| | R-6 + R-13 | 19 | 0.070 | N/A | N/A | N/A | N/A | N/A | N/A |
| | R-10 + R-13 | 23 | 0.061 | N/A | N/A | N/A | N/A | N/A | N/A |
| | R-13 + R-13 | 26 | 0.057 | N/A | N/A | N/A | N/A | N/A | N/A |
| | R-19 + R-13 | 32 | 0.048 | N/A | N/A | N/A | N/A | N/A | N/A |

*Modify Appendix A as follows (SI units):*

**A2.3 Metal Building Roofs**

**A2.3.1 General.** For the purpose of A1.2, the base assembly is a *roof* with *thermal spacer blocks* where the insulation is draped over the steel structure (purlins), spaced nominally 1.52 m on center, and ~~then~~ compressed when the metal roof panels are attached to the steel structure (purlins). ~~Additional assemblies include *continuous insulation*, uncompressed and uninterrupted by framing.~~

**A2.3.2 Rated R-Value of insulation**

**A2.3.2.1** The first *rated R-value of insulation* is for insulation draped over purlins and then compressed when the metal roof panels are attached, or for insulation hung between the purlins. A minimum R-0.6~~1 in.~~ thermal spacer block between the purlins and the metal roof panels is required when specified in Table A2.3.

**A2.3.2.2** For double-layer installations, the second *rated R-value of insulation* is for insulation installed parallel to the purlins.

**A2.3.2.3** For continuous insulation (e.g., insulation boards or blankets), it is assumed that the insulation is installed below the purlins and is uninterrupted by framing members. Insulation exposed to the *conditioned space* or *semiheated space* shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

**A2.3.2.4 *Liner System* (Ls).** A continuous vapor barrier liner is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the liner between the purlins. For multilayer installations, the *first rated R-value of insulation* is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-0.6 thermal spacer block between the purlins and the metal roof panels is required when specified in Table A2.3.

**A2.3.3 U-Factor.** *U-factors* for *metal building roofs* shall be taken from Table A2.3 It is not acceptable to use these *U-factors* if additional insulated sheathing is not continuous.

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**Exception to A3.1.3.1:** For *mass walls*, where the requirement in Tables 5.5-1 through 5.5-8 is for a maximum assembly U-0.857 followed by footnote "~~a~~b," …

*The remainder of Appendix A is unchanged.*

*Modify Tables A2.3 and A3.2 as follows (SI units):*

**TABLE A2.3 Assembly U-Factors for Metal Building Roofs**

| Insulation System | Rated R-Value of Insulation | Total Rated R-Value of Insulation | Overall U-Factor for Entire Base Roof Assembly | Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (Uninterrupted by Framing) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Rated R-Value of Continuous Insulation | | | | | |
| | | | | R-1.0 | R-2.0 | R-3.0 | R-4.0 | R-4.9 | R-5.9 |
| **Standing Seam Roofs with Thermal Spacer Blocks** | | | | | | | | | |
| Single Layer | None | 0 | **U-7.258** | ~~0.919~~ 0.891 | ~~0.493~~ 0.471 | ~~0.335~~ 0.324 | ~~0.255~~ 0.244 | ~~0.204~~ 0.199 | ~~1.070~~ 0.165 |
| | R-1.1 | 1.1 | **U-0.947** | 0.489 | 0.330 | 0.249 | 0.200 | 0.167 | 0.143 |
| | R-1.8 | 1.8 | **U-0.550** | 0.356 | 0.264 | 0.209 | 0.173 | 0.148 | 0.129 |
| | R-1.9 | 1.9 | **U-0.522** | 0.344 | 0.257 | 0.205 | 0.170 | 0.146 | 0.128 |
| | R-2.3 | 2.3 | **U-0.471** | 0.321 | 0.244 | 0.197 | 0.165 | 0.142 | 0.124 |
| | R-2.8 | 2.8 | **U-0.408** | 0.291 | 0.226 | 0.185 | 0.156 | 0.135 | 0.119 |
| | R-3.3 | 3.3 | **U-0.369** | 0.270 | 0.213 | 0.176 | 0.150 | 0.131 | 0.116 |
| Double Layer | R-1.8 + R-1.8 | 3.5 | **U-0.357** | 0.264 | 0.209 | 0.174 | 0.148 | 0.129 | 0.115 |
| | R-1.8 + R-1.9 | 3.7 | **U-0.346** | 0.258 | 0.205 | 0.171 | 0.146 | 0.128 | 0.113 |
| | R-1.9 + R-1.9 | 3.9 | **U-0.340** | 0.255 | 0.203 | 0.169 | 0.145 | 0.127 | 0.113 |
| | R-1.8 + R-2.3 | 4.1 | **U-0.329** | 0.248 | 0.199 | 0.167 | 0.143 | 0.125 | 0.112 |
| | R-1.9 + R-2.3 | 4.2 | **U-0.323** | 0.245 | 0.197 | 0.165 | 0.142 | 0.124 | 0.111 |
| | R-2.3 + R-2.3 | 4.6 | **U-0.312** | 0.238 | 0.193 | 0.162 | 0.140 | 0.123 | 0.109 |
| | R-1.8 + R-3.3 | 5.1 | **U-0.295** | 0.228 | 0.186 | 0.157 | 0.136 | 0.120 | 0.107 |
| | R-1.9 + R-3.3 | 5.3 | **U-0.289** | 0.225 | 0.184 | 0.156 | 0.135 | 0.119 | 0.107 |
| | R-2.3 + R-3.3 | 5.6 | **U-0.278** | 0.218 | 0.179 | 0.152 | 0.132 | 0.117 | 0.105 |
| | R-2.8 + R-3.3 | 6.2 | **U-0.266** | 0.211 | 0.175 | 0.149 | 0.130 | 0.115 | 0.103 |
| | R-3.3 + R-3.3 | 6.7 | **U-0.261** | 0.207 | 0.172 | 0.147 | 0.128 | 0.114 | 0.102 |
| Liner System | R-1.9 + R-3.3 | 5.3 | **0.198** | | | | | | |
| | R-1.9 + R-4.4 | 6.3 | **0.176** | | | | | | |
| | R-1.9 + R-5.3 | 7.2 | **0.165** | | | | | | |
| | R-1.9 + R-1.9 + R-4.4 | 8.3 | **0.148** | | | | | | |
| **Standing Seam Roofs without Thermal Spacer Blocks** | | | | | | | | | |
| Liner System | R-1.9 + R-3.3 | 5.3 | **0.227** | 0.185 | 0.157 | 0.136 | 0.120 | 0.107 | 0.097 |
| **Filled Cavity with Thermal Spacer Blocks** | | | | | | | | | |
| | R-3.3 + R-1.8 | 5.1 | **U-0.232** | 0.189 | 0.159 | 0.138 | 0.121 | 0.108 | 0.098 |
| (Multiple R-values are listed in order from inside to outside.) | | | | | | | | | |
| **Thru-Fastened Roofs without Thermal Spacer Blocks** | | | | | | | | | |
| | R-1.8 | 1.8 | **U-0.868** | | | | | | |
| | R-1.9 | 1.9 | **U-0.788** | | | | | | |
| | R-2.3 | 2.3 | **U-0.737** | | | | | | |
| | R-2.8 | 2.8 | **U-0.660** | | | | | | |
| | R-3.3 | 3.3 | **U-0.550** | | | | | | |
| Liner System | R-1.9 + R-3.3 | 5.3 | **0.249** | | | | | | |

## TABLE A3.2 Assembly U-Factors for Metal Building Walls

| Insulation System | Rated R-Value of Insulation | Total Rated R-Value of Insulation | Overall U-Factor for Entire Base Wall Assembly | Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Rated R-Value of Continuous Insulation | | | | | |
| | | | | R-1.0 | R-2.0 | R-3.0 | R-4.0 | R-4.9 | R-5.9 |
| **Single Layer of Mineral Fiber** | | | | | | | | | |
| | None | 0.0 | **6.69** | ~~0.91~~ 0.88 | ~~0.49~~ 0.47 | ~~0.33~~ 0.32 | ~~0.26~~ 0.24 | 0.20 | ~~0.17~~ 0.16 |
| | R-1.1 | 1.1 | **1.04** | 0.51 | 0.34 | 0.26 | 0.20 | 0.17 | 0.15 |
| | R-1.8 | 1.8 | **0.76** | 0.43 | 0.30 | 0.23 | 0.19 | 0.16 | 0.14 |
| | R-1.9 | 1.9 | **0.70** | 0.41 | 0.29 | 0.23 | 0.19 | 0.16 | 0.14 |
| | R-2.3 | 2.3 | **0.64** | 0.39 | 0.28 | 0.22 | 0.18 | 0.15 | 0.13 |
| | R-2.8 | 2.8 | **0.53** | 0.35 | 0.26 | 0.20 | 0.17 | 0.15 | 0.13 |
| | R-3.3 | 3.3 | **0.48** | 0.32 | 0.24 | 0.20 | 0.16 | 0.14 | 0.12 |
| **Double Layer of Mineral Fiber** | | | | | | | | | |
| (Second layer inside of girts) | | | | | | | | | |
| (Multiple layers are listed in order from inside to outside) | | | | | | | | | |
| | R-1.1 + R-2.3 | 3.4 | **0.40** | N/A | N/A | N/A | N/A | N/A | N/A |
| | R-1.8 + R-2.3 | 4.1 | **0.35** | N/A | N/A | N/A | N/A | N/A | N/A |
| | R-2.3 + R-2.3 | 4.6 | **0.32** | N/A | N/A | N/A | N/A | N/A | N/A |
| | R-3.3 + R-2.3 | 5.6 | **0.27** | N/A | N/A | N/A | N/A | N/A | N/A |

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*This change includes a new exception to Section 6.5.2.1 that is geared toward zones with direct digital controls (DDC). The new exception (exception b) largely addresses the apparent conflict between Standards 55, 62.1, and 90.1, and also takes advantage of the energy-saving potential of DDC controls in order to save about \$0.20/ft$^2$/yr with a simple payback of less than two years. The apparent conflict is that the current 30% reheat maximum typically requires very high supply air temperatures (e.g., >100°F) to meet peak heating load. High supply air temperatures result in poor comfort per Standard 55 and poor ventilation effectiveness per Standard 62.1. The new exception allows reheat to increase from 30% to 50%, which means lower supply air temperatures and better comfort and ventilation effectiveness. The energy savings come from the fact that maximum airflow in deadband is being lowered from 30% to 20%. This saves fan energy and cooling energy in deadband, and also reduces the amount of time when the zone will be overcooled in deadband and forced into reheat.*

*This new exception will also alleviate a common problem where engineers feel compelled to violate the current 30% exception in order to provide adequate heating. In addition to poor comfort and ventilation effectiveness, high supply air temperatures also lead to short-circuiting. When hot supply air short circuits directly from the supply to the return, the space takes longer to warm up and may not warm up at all. Therefore, it is very common for designers and contractors to disregard the current 30% requirement and use 40% or 50% minimum flow setpoints to ensure adequate heating. No one likes to disregard the code, but if the choice is between code and comfort, comfort wins. The new exception allows users to achieve comfort, meet the code, and save energy at minimal cost.*

*Because not all zones have DDC controls and because this is a fairly significant shift in zone controls, the existing 30% exception is left in the standard. However, two clauses from the existing exception are deleted. The 0.4 cfm/ft$^2$ exception is deleted because it implies that a minimum air speed in the occupied space is required for comfort. ASHRAE Standard 55, however, indicates that no minimum air speed is required for comfort. Furthermore. 0.4 cfm/ft$^2$ does not guarantee any particular air speed because 0.4 cfm/ft$^2$ can be a small fraction (e.g., 10%) or a large fraction (e.g., 50%) of the design flow rate and, thus, can result in a low or high air speed. The 300 cfm exception is deleted because the situation that it was intended to address has been largely eliminated by the new 50% exception described above. This criterion was intended to address the following applications: the occasional small zone in a VAV reheat system for which 30% is insufficient to handle heating loads, such as spaces with large north-facing glass areas..*

## Addendum h to Standard 90.1-2007

*Revise the standard as follows (I-P and SI units):*

*Revise exceptions to Section 6.5.2.1 as follows:*

~~**Exceptions to 6.5.2.1:**~~

~~a. Zones for which the volume of air that is reheated, recooled, or mixed is no greater than the larger of the following:~~

~~1. The volume of *outdoor air* required to meet the ventilation requirements of Section 6.2 of ASHRAE Standard 62.1 for the *zone*,~~
~~2. 0.4 cfm/ft2 [2L/s/m2] of the *zone* conditioned floor area,~~
~~3. 30% of the zone design peak supply rate,~~
~~4. 300 cfm [140L/s] – this exception is for zones whose peak flow rate totals no more than 10% of the total fan system flow rate,~~
~~5. Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in outdoor air intake for the system.~~

**Exceptions to 6.5.2.1:**

a. *Zones* for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:

1. 30% of the *zone* design peak supply rate;
2. The volume of *outdoor air* required to meet the ventilation requirements of Section 6.2 of ASHRAE Standard 62.1 for the *zone*;
3. Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in *outdoor air* intake.

b. *Zones* that comply with all of the following:

1. The volume of air that is reheated, recooled, or mixed in *dead band* between heating and cooling does not exceed the larger of the following:

a. 20% of the *zone* design peak supply rate;
b. the volume of *outdoor air* required to meet the ventilation requirements of Section 6.2 of ASHRAE Standard 62.1 for the *zone*;
c. any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall system

annual energy usage by offsetting reheat/ recool energy losses through a reduction in *outdoor air* intake.

2. The volume of air that is reheated, recooled, or mixed in peak heating demand shall be less than 50% of the *zone* design peak supply rate.
3. Airflow between *dead band* and full heating or full cooling shall be modulated.

~~b~~c.) *Zones* where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that variable-air-volume systems are impractical.

~~c~~d.) *Zones* where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a *site-recovered* (including condenser heat) or *site- solar energy source.*

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

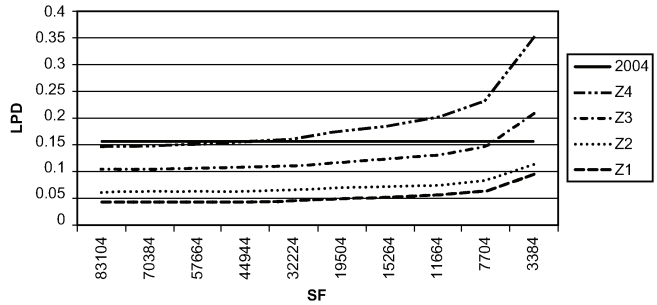
## FOREWORD

*This proposal will apply a four-zone lighting power density approach to exterior lighting requirements. This approach recognizes the varying lighting needs and design differences associated with different building locations. It is acceptable and prudent to reduce the light levels as the designer leaves the downtown city center entering into mixed commercial/ high-rise residential districts, then enters into residential areas, and then into rural areas. Several organizations, including the IESNA have been working to develop a zonal approach to exterior lighting recommended practice and this change in the standard will follow that guidance.*

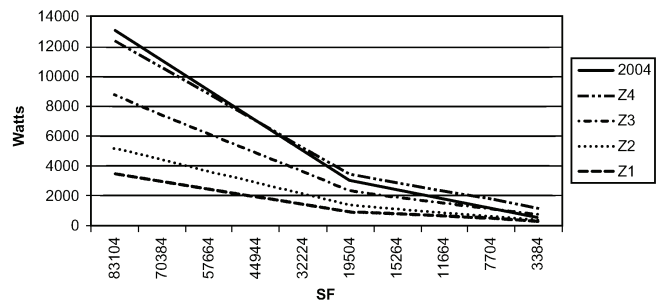
*The specific IESNA documents used in this proposal are RP-20, DG-5, IESNA Handbook, RP-2, G-1 and RP-33. There are some instances where IESNA recommendations in these documents are available for all four zone criteria, but in many cases only three light level recommendations were found and referenced. Other standards use a multizone system to either classify LPD, lumen, or light trespass requirements—California T-24 (4-zone W/sf), the upcoming MOL (5-zone Lumen/sf, and LEED (light trespass). These standards were evaluated and in some cases incorporated into this proposal.*

*The first change in Section 9.4.5 is the deletion of the 5% additional power allowances, which is replaced by a base wattage allowance per site. The second change to this section is to define the four zones and apply appropriate requirements. The four zones are based on IESNA and other group definitions to match other requirements and guidance expected to be encountered by designers. The majority of building sites will fall into LZ3, LZ2, or LZ1, and the sites that remain in LZ4 will generally be of relatively small sizes. The added "Base Site Allowance" for each zone takes into account that most sites are not rectangular or match the iso-diagram of typical light luminaires.*

*The associated energy change from this proposal comes from the lower illuminance requirements for primarily zones 1–3, where the majority of buildings are constructed. Numerous point-by-point lighting calculations were performed for parking lots, walkways, stairways, pedestrian tunnels, entries (with and without canopies), sales canopies, service stations, and auto dealerships for the four zones. In the initial calculations for the parking lots, there was a noticeable difficulty in achieving the recommended light level when the space was 20,000 ft$^2$ and lower, without any additional power allowance (this was especially true in zone 4). Six odd shaped parking lots were modeled for all four lighting zones to verify that the requirement would cover varying design needs. This modeling was used to determine appropriate base site allowances. Because of the base site allowance, the actual LPDs are on a sliding scale, as shown below.*




*The energy savings from this zone approach is shown in the chart below, with total energy used in each lighting zone for the various square footages. The solid line is the current 2004 standard.*




## Addendum i to Standard 90.1-2007

*Revise the Standard as follows (I-P units):*

**9.4.5 Exterior Building Lighting Power.** The total *exterior lighting power allowance* for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are designed to be illuminated and are ~~lighting power densities~~ permitted in Table 9.4.6~~5~~ for the applicable lighting zone ~~for these applications plus an additional unrestricted allowance of 5% of that sum.~~ Trade-offs are allowed only among exterior lighting applications listed in the Table 9.4.6~~5~~ "Tradable Surfaces" section. The lighting zone for the building exterior is determined from Table 9.4.5 unless otherwise specified by the local jurisdiction.

**Exceptions to 9.4.5:** Lighting used for the following exterior applications is exempt when equipped with a *control device* that complies with the requirements of Section 9.4.1.3 and is independent of the control of the nonexempt lighting:

a. Specialized signal, directional, and marker lighting associated with transportation.
b. Advertising signage or directional signage.
c. Lighting integral to *equipment* or instrumentation and installed by its *manufacturer*.

## TABLE 9.4.5 Exterior Lighting Zones

| Lighting Zone | Description |
|---|---|
| 1 | Developed areas of national parks, state parks, forest land, and rural areas |
| 2 | Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited night-time use and residential mixed use areas |
| 3 | All other areas |
| 4 | High activity commercial districts in major metropolitan areas as designated by the local jurisdiction |

## TABLE 9.4.6.~~5~~ Individual Lighting Power Allowances~~Densities~~ for Building Exteriors

| | | Zone 1 | Zone 2 | Zone 3 | Zone 4 |
|---|---|---|---|---|---|
| **Base Site Allowance** (base allowance may be used in tradable or non-tradable surfaces) | | 500 W | 600 W | 750 W | 1300 W |
| **Tradable Surfaces** (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and over-hangs and outdoor sales areas may be traded.) | **Uncovered Parking Areas** | | | | |
| | Parking ~~Lots~~ areas and drives | 0.04 W/ft$^2$ | 0.06 W/ft$^2$ | 0.10 W/ft$^2$ | ~~0.15~~0.13 W/ft$^2$ |
| | **Building Grounds** | | | | |
| | Walkways less than 10 feet wide | 0.7 W/linear foot | 0.7 W/linear foot | 0.8 W/linear foot | 1.0 W/linear foot |
| | Walkways 10 feet wide or greater<br>Plaza areas<br>Special Feature Areas | 0.14 W/ft$^2$ | 0.14 W/ft$^2$ | 0.16 W/ft$^2$ | 0.2 W/ft$^2$ |
| | Stairways | 0.75 W/ft$^2$ | 1.0 W/ft$^2$ | 1.0 W/ft$^2$ | 1.0 W/ft$^2$ |
| | Pedestrian tunnels | 0.15 W/ft$^2$ | 0.15 W/ft$^2$ | 0.2 W/ft$^2$ | 0.3 W/ft$^2$ |
| | Landscaping | 0.04 W/ft$^2$ | 0.05 W/ft$^2$ | 0.05 W/ft$^2$ | 0.05 W/ft$^2$ |
| | **Building Entrances and Exits** | | | | |
| | Main entries | 20 W/linear foot of door width | 20 W/linear foot of door width | 30 W/linear foot of door width | 30 W/linear foot of door width |
| | Other doors | 20 W/linear foot of door width | 20 W/linear foot of door width | 20 W/linear foot of door width | 20 W/linear foot of door width |
| | Entry canopies | 0.25 W/ft$^2$ | 0.25 W/ft$^2$ | 0.4 W/ft$^2$ | ~~1.25~~0.4 W/ft$^2$ |
| | **Sales Canopies ~~and Overhangs~~** | | | | |
| | ~~Canopies (~~free standing and attached ~~and over-hangs)~~ | 0.6 W/ft$^2$ | 0.6 W/ft$^2$ | 0.8 W/ft$^2$ | ~~1.25~~1.0 W/ft$^2$ |
| | **Outdoor Sales** | | | | |
| | Open areas (including vehicle sales lots) | 0.25 W/ft$^2$ | 0.25 W/ft$^2$ | 0.5 W/ft$^2$ | 0.~~5~~ 7 W/ft$^2$ |
| | Street frontage for vehicle sales lots in addition to "open area" allowance | **No allowance** | 10 W/linear foot | 10 W/linear foot | ~~20~~ 30 W/linear foot |

**TABLE 9.4.6.~~5~~ Individual Lighting Power Allowances~~Densities~~ for Building Exteriors (Continued)**

| | | | | | |
|---|---|---|---|---|---|
| **Non-Tradable Surfaces** (Lighting power density calculations for the following applications can be used only for the specific application and can-not be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "tradable Surfaces" section of this table.) | **Building Facades** | No allowance | 0.1 W/ft$^2$ for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length | 0.15 W/ft$^2$ for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length | 0.2 W/ft$^2$ for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length |
| | **Automated teller machines and night depositories** | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location |
| | **Entrances and gatehouse inspection stations at guarded facilities** | 0.75 W/ft$^2$ of covered and uncovered area | 0.75 W/ft$^2$ of covered and uncovered area | 0.75 W/ft$^2$ of covered and uncovered area | ~~1.25~~0.75 W/ft$^2$ of covered and uncovered area ~~(covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")~~ |
| | **Loading areas for law enforcement, fire, ambulance and other emergency service vehicles** | 0.5 W/ft$^2$ of covered and uncovered area | 0.5 W/ft$^2$ of covered and uncovered area | 0.5 W/ft$^2$ of covered and uncovered area | 0.5 W/ft$^2$ of covered and uncovered area ~~(covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")~~ |
| | **Drive-up windows/doors ~~at fast food restaurants~~** | 400 W per drive-through | 400 W per drive-through | 400 W per drive-through | 400 W per drive-through |
| | **Parking near 24-hour retail entrances** | 800 W per main entry | 800 W per main entry | 800 W per main entry | 800 W per main entry |

d. Lighting for theatrical purposes, including performance, stage, film production, and video production.
e. Lighting for athletic playing areas.
f. Temporary lighting.
g. Lighting for industrial production, material handling, transportation sites, and associated storage areas.
h. Theme elements in theme/amusement parks.
i. Lighting used to highlight features of public monuments and registered *historic* landmark structures or *buildings.*

*Revise the Standard as follows (SI units):*

**9.4.5 Exterior Building Lighting Power.** The total *exterior lighting power allowance* for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are designed to be illuminated and are ~~lighting power densities~~ permitted in Table 9.4.6~~5~~ for the applicable lighting zone ~~for these applications plus an additional unrestricted allowance of 5% of that sum.~~ Trade-offs are allowed only among exterior lighting applications listed in the Table 9.4.6~~5~~ "Tradable Surfaces" section. The lighting zone for the building exterior is determined from Table 9.4.5 unless otherwise specified by the local jurisdiction.

**Exceptions to 9.4.5:** Lighting used for the following exterior applications is exempt when equipped with a *control device* that complies with the requirements of Section 9.4.1.3 and is independent of the control of the nonexempt lighting:

a. Specialized signal, directional, and marker lighting associated with transportation.
b. Advertising signage or directional signage.
c. Lighting integral to *equipment* or instrumentation and installed by its *manufacturer.*
d. Lighting for theatrical purposes, including performance, stage, film production, and video production.
e. Lighting for athletic playing areas.
f. Temporary lighting.
g. Lighting for industrial production, material handling, transportation sites, and associated storage areas.
h. Theme elements in theme/amusement parks.
i. Lighting used to highlight features of public monuments and registered *historic* landmark structures or *buildings.*

## TABLE 9.4.5 Exterior Lighting Zones

| Lighting Zone | Description |
|---|---|
| 1 | Developed areas of national parks, state parks, forest land, and rural areas |
| 2 | Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas |
| 3 | All other areas |
| 4 | High activity commercial districts in major metropolitan areas as designated by the local jurisdiction |

## TABLE 9.4.6.~~5~~ Individual Lighting Power Allowances~~Densities~~ for Building Exteriors

| | | Zone 1 | Zone 2 | Zone 3 | Zone 4 |
|---|---|---|---|---|---|
| **Base Site Allowance** (base allowance may be used in tradable or non-tradable surfaces) | | 500 W | 600 W | 750 W | 1300 W |
| **Tradable Surfaces** (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and over-hangs and outdoor sales areas may be traded.) | **Uncovered Parking Areas** | | | | |
| | Parking ~~Lots~~ areas and drives | 0.43 W/m$^2$ | 0.65 W/m$^2$ | 1.1 W/m$^2$ | ~~0.15~~1.4 W/m$^2$ |
| | **Building Grounds** | | | | |
| | Walkways less than 10 feet wide | 2.3 W/linear meter | 2.3 W/linear meter | 2.6 W/linear meter | 3.3 W/linear meter |
| | Walkways 10 feet wide or greater<br>Plaza areas<br>Special Feature Areas | 1.5 W/m$^2$ | 1.5 W/m$^2$ | 1.7 W/m$^2$ | 2.2 W/m$^2$ |
| | Stairways | 8.1 W/m$^2$ | 10.8 W/m$^2$ | 10.8 W/m$^2$ | 10.8 W/m$^2$ |
| | Pedestrian tunnels | 1.6 W/m$^2$ | 1.6 W/m$^2$ | 2.2 W/m$^2$ | 3.2 W/m$^2$ |
| | Landscaping | 0.43 W/m$^2$ | 0.54 W/m$^2$ | 0.54 W/m$^2$ | 0.54 W/m$^2$ |
| | **Building Entrances and Exits** | | | | |
| | Main entries | 66 W/linear meter of door width | 66 W/linear meter of door width | 98 W/linear meter of door width | 98 W/linear meter of door width |
| | Other doors | 66 W/linear meter of door width | 66 W/linear meter of door width | 66 W/linear meter of door width | 66 W/linear meter of door width |
| | Entry canopies | 2.7 W/m$^2$ | 2.7 W/m$^2$ | 4.3 W/m$^2$ | ~~1.25~~4.3 W/m$^2$ |
| | **Sales Canopies ~~and Overhangs~~** | | | | |
| | ~~Canopies (~~free standing and attached ~~and over-hangs)~~ | 6.5 W/m$^2$ | 6.5 W/m$^2$ | 8.6 W/m$^2$ | ~~1.25~~10.8 W/m$^2$ |
| | **Outdoor Sales** | | | | |
| | Open areas (including vehicle sales lots) | 2.7 W/m$^2$ | 2.7 W/m$^2$ | 5.4 W/m$^2$ | 0.~~5~~ 7.5 W/m$^2$ |
| | Street frontage for vehicle sales lots in addition to "open area" allowance | **No allowance** | 33 W/linear meter | 33 W/linear meter | ~~20~~ 98 W/linear meter |

**TABLE 9.4.6.~~5~~ Individual Lighting Power Allowances~~Densities~~ for Building Exteriors (Continued)**

| | | | | | |
|---|---|---|---|---|---|
| **Non-Tradable Surfaces** (Lighting power density calculations for the following applications can be used only for the specific application and can-not be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "tradable Surfaces" section of this table.) | **Building Facades** | **No allowance** | 1.1 W/m$^2$ for each illuminated wall or surface or 8.2 W/linear meter for each illuminated wall or surface length | 1.6 W/m$^2$ for each illuminated wall or surface or 12.3 W/linear meter for each illuminated wall or surface length | 2.2 W/m$^2$ for each illuminated wall or surface or 16.4 W/linear meter for each illuminated wall or surface length |
| | **Automated teller machines and night depositories** | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location |
| | **Entrances and gatehouse inspection stations at guarded facilities** | 8.1 W/m$^2$ of covered and uncovered area | 8.1 W/m$^2$ of covered and uncovered area | 8.1 W/m$^2$ of covered and uncovered area | ~~1.25~~8.1 W/m$^2$ of covered and uncovered area ~~(covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")~~ |
| | **Loading areas for law enforcement, fire, ambulance and other emergency service vehicles** | 5.4 W/m$^2$ of covered and uncovered area | 5.4 W/m$^2$ of covered and uncovered area | 5.4 W/m$^2$ of covered and uncovered area | 5.4 W/m$^2$ of covered and uncovered area ~~(covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")~~ |
| | **Drive-up windows/ doors ~~at fast food restaurants~~** | 400 W per drive-through | 400 W per drive-through | 400 W per drive-through | 400 W per drive-through |
| | **Parking near 24-hour retail entrances** | 800 W per main entry | 800 W per main entry | 800 W per main entry | 800 W per main entry |

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## FOREWORD

*This addendum is intended to update the mechanical test procedures and references in ANSI/ASHRAE/IESNA Standard 90.1-2007. The changes modify a reference in Table 6.8.1E, the normative references in Chapter 12, and the informative references in Informative Appendix E.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum j to Standard 90.1-2007

*Revise as follows (I-P and SI units):*

*Modify Section 12, Normative References, as follows.*

| Reference | Title |
|---|---|
| ~~AMCA 500-D-98~~ | ~~Test Methods for Louvers, Dampers and Shutters~~ |
| AMCE 500-D-07 | Laboratory Methods of Testing Dampers for Rating |
| ANSI Z21.10.3-~~1998~~ 2004 | Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h, Circulating and Instantaneous Water Heaters |
| ANSI Z21.47-~~2001~~ 2006 | Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustions System Furnaces) |
| ANSI Z21.83.8-~~2002~~ 2006 | Gas Unit Heaters and Duct Furnaces |
| ANSI/AHAM RAC-1-~~87~~ 2003 | Room Air Conditioners |
| ARI 210/240-~~2003~~2006 | Unitary Air Conditioning and Air-Source Heat Pump Equipment |
| ARI 460-~~2000~~ 2005 | Remote Mechanical Draft Air Cooled Refrigerant Condensers |
| ARI 550/590-~~98~~ 2003 | Water-Chilling Packages Using the Vapor Compression Cycle |
| UL 181A-~~94~~ 2005 | Closure Systems for Use with Rigid Air Ducts and Air Connectors |
| UL 181B-~~95~~ 2006 | Closure Systems for Use with Flexible Air Ducts and Air Connectors |
| ANSI/ASHRAE 146-~~1998~~ 2006 | Method of Testing for Rating Pool Heaters |

*Modify Informative Appendix E as follows.*

**(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

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Cool Roof Rating Council
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(F) 510-482-4421
www.coolroofs.org

| | |
|---|---|
| CRRC-1-~~2002~~ 2006 | Cool Roof Rating Council Product Rating Program |
| *200~~1~~5 ASHRAE Handbook—Fundamentals* | ASHRAE |
| MICA Insulation Standards~~—1999~~ 6th Edition | National Commercial and Industrial Insulation Standards |
| SMACNA Duct Construction Standards~~—1995~~ 2005 | HVAC Duct Construction Standards, Metal and Flexible |
| *200~~3~~7 ASHRAE Handbook—HVAC Applications* | Chapter 49, Service Water Heating/ASHRAE |
| AABC 2002 | ~~Associated Air Balance Council Test and Balance Procedures~~ Associated Air Balance Council, National Standards for Total System Balance |

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## FOREWORD

*This addendum revises Tables 6.8.1E and 7.8 in ANSI/ASHRAE/IESNA Standard 90.1-2007, identifying the specific sections of the referenced standards. Table 7.8 is also updated to reflect the current federal efficiency levels for residential water heaters. Additionally, a requirement in Table 7.8 for electric table top water heaters has been added.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum k to Standard 90.1-2007

*Revise as follows (I-P units):*

**TABLE 6.8.1E Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces, and Unit Heaters**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency[a] | Test Procedure[b] |
|---|---|---|---|---|
| Warm Air Furnace, Gas-Fired | <225,000 Btu/h | | 78% AFUE or 80% $E_{td}$ | DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, of ANSI Z21.47 |
| | ≥225,000 Btu/h | Maximum Capacity[d] | 80% $E_{cc}$ | Section 2.39, Thermal Efficiency, of ANSI Z21.47 |
| Warm Air Furnace, Oil-Fired | <225,000 Btu/h | | 78% AFUE or 80%$E_{td}$ | DOE 10 CFR Part 430 or Section 42, Combustion, of UL 727 |
| | ≥225,000 Btu/h | Maximum Capacity[e] | 81% $E_{tf}$ | Section 42, Combustion, of UL 727 |
| Warm Air Duct Furnaces, Gas- Fired | All Capacities | Maximum Capacity[e] | 80% $E_{cg}$ | Section 2.10, Efficiency, of ANSI Z83.~~9~~8 |
| Warm Air Unit Heaters, Gas-Fired | All Capacities | Maximum Capacity[e] | 80% $E_{cg}$ | Section 2.10, Efficiency, of ANSI Z83.8 |
| Warm Air Unit Heaters, Oil-Fired | All Capacities | Maximum Capacity[e] | 80% $E_{cg}$ | Section 40, Combustion, of UL 731 |

[a] $E_t$= thermal *efficiency*. See test procedure for detailed discussion.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[c] $E_c$ = combustion *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[d] Combination units not covered by NAECA (three-phase power or cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating.
[e] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[f] $E_t$ = thermal *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[g] $E_c$ = combustion *efficiency* (100% less flue losses). See test procedure for detailed discussion.

*Revise as follows (I-P units):*

**TABLE 7.8 Performance Requirements for Water Heating Equipment**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Performance Required[a] | Test Procedure[b, c] |
|---|---|---|---|---|
| Electric Table Top Water Heaters | ≤12 kW | Resistance ≥20 gal | 0.93-0.00132V EF | DOE 10 CFR Part 430 |
| Electric Water Heaters | ≤12 kW | Resistance ≥20 gal | 0.9~~3~~7-0.00132V EF | DOE 10 CFR Part 430 |
| | >12 kW | Resistance≥20 gal | 20 + 35 √V SL, Btu/h | Section G.2 of ANSI Z21.10.3 |
| | ≤24 Amps and ≤250 Volts | Heat Pump | 0.93-0.00132V EF | DOE 10 CFR Part 430 |
| Gas Storage Water Heaters | ≤75,000 Btu/h | ≥20 gal | 0.6~~2~~7-0.0019V EF | DOE 10 CFR Part 430 |
| | >75,000 Btu/h | <4000 (Btu/h)/gal | 80% $E_t$ (Q/800 + 110 √V) SL, Btu/h | Sections G.1 and G.2 of ANSI Z21.10.3 |
| Gas Instantaneous Water Heaters | >50,000 Btu/h and <200,000 Btu/h | ≥4000 (Btu/h)/gal and <2 gal | 0.62-0.0019V EF | DOE 10 CFR Part 430 |
| | ≥200,000 Btu/h[e d] | ≥4000 (Btu/h)/gal and <10 gal | 80% $E_t$ | Sections G.1 and G.2 of ANSI Z21.10.3 |
| | ≥200,000 Btu/h | ≥4000 (Btu/h)/gal and ≥10 gal | 80% $E_t$ (Q/800 + 110 √V) SL, Btu/h | |
| Oil Storage Water Heaters | ≤105,000 Btu/h | ≥20 gal | 0.59-0.0019V EF | DOE 10 CFR Part 430 |
| | >105,000 Btu/h | <4000 (Btu/h)/gal | 78% $E_t$ (Q/800 + 110 √V) SL, Btu/h | Sections G.1 and G.2 of ANSI Z21.10.3 |
| Oil Instantaneous Water Heaters | ≤210,000 Btu/h | ≥4000 (Btu/h)/gal and <2 gal | 0.59-0.0019V EF | DOE 10 CFR Part 430 |
| | >210,000 Btu/h | ≥4000 (Btu/h)/gal and <10 gal | 80% $E_t$ | Sections G.1 and G.2 of ANSI Z21.10.3 |
| | >210,000 Btu/h | ≥4000 (Btu/h)/gal and ≥10 gal | 78% $E_t$ (Q/800 + 110 √V) SL, Btu/h | |
| Hot Water Supply Boilers, Gas and Oil | ≥300,000 Btu/h and <12,500,000 Btu/h | ≥4000 (Btu/h)/gal and <10 gal | 80% $E_t$ | Sections G.1 and G.2 of ANSI Z21.10.3 |
| Hot Water Supply Boilers, Gas | | ≥4000 (Btu/h)/gal and ≥10 gal | 80% $E_t$ (Q/800 + 110 √V) SL, Btu/h | |
| Hot Water Supply Boilers, Oil | | ≥4000 (Btu/h)/gal and ≥10 gal | 78% $E_t$ (Q/800 + 110 √V) SL, Btu/h | |
| Pool Heaters Oil and Gas | All | | 78% $E_t$ | ASHRAE 146 |
| Heat Pump Pool Heaters | All | | 4.0 COP | ASHRAE 146 |
| Unfired Storage Tanks | All | | R-12.5 | (none) |

[a] Energy factor (EF) and thermal efficiency ($E_t$) are minimum requirements, while standby loss (SL) is maximum Btu/h based on a 70°F temperature difference between stored water and ambient requirements. In the EF equation, $V$ is the rated volume in gallons. In the SL equation, $V$ is the rated volume in gallons and $Q$ is the nameplate input rate in Btu/h.
[b] Section 12 contains a complete specification, including the year version, of the referenced test procedure.
[c] Section G1 is titled "Test Method for Measuring Thermal Efficiency" and Section G2 is titled "Test Method for Measuring Standby Loss."
[ed] Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

*Revise as follows (SI units):*

**TABLE 6.8.1E Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces, and Unit Heaters**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency[a] | Test Procedure[b] |
|---|---|---|---|---|
| Warm Air Furnace, Gas-Fired | <66 kW | | 78% AFUE or 80% $E_{td}$ | DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, of ANSI Z21.47 |
| | ≥66 kW | Maximum Capacity[d] | 80% $E_{cc}$ | Section 2.39, Thermal Efficiency, of ANSI Z21.47 |
| Warm Air Furnace, Oil-Fired | <66 kW | | 78% AFUE or 80%$E_{td}$ | DOE 10 CFR Part 430 or Section 42, Combustion, of UL 727 |
| | ≥66 kW | Maximum Capacity[e] | 81% $E_{tf}$ | Section 42, Combustion, of UL 727 |
| Warm Air Duct Furnaces, Gas-Fired | All Capacities | Maximum Capacity[e] | 80% $E_{cg}$ | Section 2.10, Efficiency, of ANSI Z83.8 |
| Warm Air Unit Heaters, Gas-Fired | All Capacities | Maximum Capacity[e] | 80% $E_{cg}$ | Section 2.10, Efficiency, of ANSI Z83.8 |
| Warm Air Unit Heaters, Oil-Fired | All Capacities | Maximum Capacity[e] | 80% $E_{cg}$ | Section 40, Combustion, of UL 731 |

[a] $E_t$= thermal *efficiency.* See test procedure for detailed discussion.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[c] $E_c$ = combustion *efficiency.* Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[d] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 19 kW) may comply with either rating.
[e] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[f] $E_t$ = thermal *efficiency.* Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[g] $E_c$ = combustion *efficiency* (100% less flue losses). See test procedure for detailed discussion.

*Revise as follows (SI units):*

**TABLE 7.8 Performance Requirements for Water Heating Equipment**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | (SI Criteria) Performance Required[a] | Test Procedure[b,c] |
|---|---|---|---|---|
| Electric Table Top Water Heaters | ≤12 kW | Resistance ≥75.7 L | 0.93-0.00035V EF | DOE 10 CFR Part 430 |
| Electric Water Heaters | ≤12 kW | Resistance ≥75.7 L | 0.9~~3~~7-0.00035V EF | DOE 10 CFR Part 430 |
| | >12 kW | Resistance≥75.7 L | 5.9 + 5.3 √V SL, W | Section G.2 of ANSI Z21.10.3 |
| | ≤24 Amps and ≤250 Volts | Heat Pump | 0.93-0.00035V EF | DOE 10 CFR Part 430 |
| Gas Storage Water Heaters | ≤22.98 kW | ≥75.7 L | 0.6~~2~~7-0.0005V EF | DOE 10 CFR Part 430 |
| | >22.98 kW | <309.75 W/L | 80% $E_t$ (Q/800 + 16.6√V) SL, W | Sections G.1 and G.2 of ANSI Z21.10.3 |
| Gas Instantaneous Water Heaters | >14.66 kW and <58.62 kW | ≥309.75 W/L and <7.57 L | 0.62-0.0005V EF | DOE 10 CFR Part 430 |
| | ≥58.62 kW[e d] | ≥309.75 W/L and <37.85 L | 80% $E_t$ | Sections G.1 and G.2 of ANSI Z21.10.3 |
| | ≥58.62 kW | ≥309.75 W/L and ≥37.85 L | 80% $E_t$ (Q/800 + 16.6 √V) SL, W | |
| Oil Storage Water Heaters | ≤30.78 kW | ≥75.7 L | 0.59-0.0005V EF | DOE 10 CFR Part 430 |
| | >30.78 kW | <309.75 W/L | 78% $E_t$ (Q/800 + 16.6√V) SL, W | Sections G.1 and G.2 of ANSI Z21.10.3 |
| Oil Instantaneous Water Heaters | ≤61.55 kW | ≥309.75 W/L and <7.57 L | 0.59-0.0005V EF | DOE 10 CFR Part 430 |
| | >61.55 kW | ≥309.75 W/L and <37.85 L | 80% $E_t$ | Sections G.1 and G.2 of ANSI Z21.10.3 |
| | >61.55 kW | ≥309.75 W/L and ≥37.85 L | 78% $E_t$ (Q/800 + 16.6√V) SL, W | |
| Hot Water Supply Boilers, Gas and Oil | ≥87.93 kW and <3663.8 kW | ≥309.75 W/L and <37.85 L | 80% $E_t$ | Sections G.1 and G.2 of ANSI Z21.10.3 |
| Hot Water Supply Boilers, Gas | | ≥309.75 W/L and ≥37.85 L | 80% $E_t$ (Q/800 + 16.6√V) SL, W | |
| Hot Water Supply Boilers, Oil | | ≥309.75 W/L and ≥37.85 L | 78% $E_t$ (Q/800 + 16.6√V) SL, W | |
| Pool Heaters Oil and Gas | All | | 78% $E_t$ | ASHRAE 146 |
| Heat Pump Pool Heaters | All | | 4.0 COP | ASHRAE 146 |
| Unfired Storage Tanks | All | | R-2.2 | (none) |

[a] Energy factor (EF) and thermal efficiency ($E_t$) are minimum requirements, while standby loss (SL) is maximum W based on a 39°C temperature difference between stored water and ambient requirements. In the EF equation, $V$ is the rated volume in liters. In the SL equation, $V$ is the rated volume in liters and $Q$ is the nameplate input rate in Watts.
[b] Section 12 contains a complete specification, including the year version, of the referenced test procedure.
[c] Section G1 is titled "Test Method for Measuring Thermal Efficiency" and Section G2 is titled "Test Method for Measuring Standby Loss."
[e d] Instantaneous water heaters with input rates below 58.62 kW must comply with these requirements if the water heater is designed to heat water to temperatures 82.2°C or higher.

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## FOREWORD

*The purpose of this addendum is to add minimum efficiency and certification requirements for both axial and centrifugal fan closed-circuit cooling towers (also known as fluid coolers) into Table 6.8.1G. In addition, a reference to ATC-105S, The Cooling Technology Institute (CTI) test standard for closed-circuit cooling towers, has been added to Section 12, Normative References. A subcommittee of ASHRAE TC 8.6, Technical Committee on Cooling Towers and Evaporative Condensers, developed this addendum, which has been unanimously supported by the entire TC.*

*Closed-circuit cooling towers differ from open-circuit cooling towers in that the process fluid is kept isolated from the open loop spray water and airflow by an intermediate heat exchanger, typically a coil. Closed-circuit devices also have an integral spray pump to recirculate the spray water over the coil. To account for this, the gpm/hp value for closed-circuit cooling towers includes both the unit fan and spray pump motors, where hp equals the sum of the fan motor and integral spray pump motor nameplate horsepower. Lastly, the minimum efficiency values for closed-circuit cooling towers are based on typical water-source heat pump conditions, as the water-source heat pump industry is the largest HVAC market for this type of equipment.*

*The addition of minimum efficiency and certification requirements will provide consulting engineers, system designers, and contractors guidelines for the selection of independently certified, energy-efficient closed-circuit cooling towers. This change will also complement the existing minimum efficiency and certification requirements for open-circuit cooling towers, helping to prevent confusion between the requirements for these two different types of cooling towers.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum l to Standard 90.1-2007

*Revise as follows (I-P units):*

**TABLE 6.8.1G Performance Requirements for Heat Rejection Equipment**

| Equipment Type~~d~~ | Total System Heat Rejection Capacity at Rated Conditions | Subcategory or Rating Condition | Performance Required[a,b,~~c~~] | Test Procedure[~~e~~d,~~e~~] |
|---|---|---|---|---|
| Propeller or Axial Fan Open-Circuit Cooling Towers | All | 95°F Entering Water<br>85°F Leaving Water<br>75°F ~~wb~~ ~~*Outdoor air*~~ *Entering wb* | ≥38.2 gpm/hp | CTI ATC-105 and CTI STD-201 |
| Centrifugal Fan Open-Circuit Cooling Towers | All | 95°F Entering Water<br>85°F Leaving Water<br>75°F ~~wb~~ ~~*Outdoor air*~~ *Entering wb* | ≥20.0 gpm/hp | CTI ATC-105 and CTI STD-201 |
| Propeller or Axial Fan Closed-Circuit Cooling Towers | All | 102°F Entering Water<br>90°F Leaving Water<br>75°F *Entering wb* | ≥14.0 gpm/hp | CTI ATC-105S and CTI STD-201 |
| Centrifugal Closed-Circuit Cooling Towers | All | 102°F Entering Water<br>90°F Leaving Water<br>75°F *Entering wb* | ≥7.0 gpm/hp | CTI ATC-105S and CTI STD-201 |
| Air-Cooled Condensers | All | 125°F Condensing Temperature<br>R-22 Test Fluid<br>190°F Entering Gas Temperature<br>15°F Subcooling<br>95°F Entering db | ≥176,000 Btu/h·hp | ARI 460 |

[a] For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 6.8.1G divided by the fan ~~nameplate rated~~ motor nameplate power.

[b] For purposes of this table, *closed-circuit cooling tower performance* is defined as the process water flow rating of the tower at the thermal rating condition listed in Table 6.8.1G divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

[~~b~~c] For purposes of this table, *air-cooled condenser performance* is defined as the heat rejected from the refrigerant divided by the fan ~~nameplate rated~~ motor nameplate power.

[~~c~~d] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[~~d~~e] ~~The efficiencies for open cooling towers listed in Table 6.8.1G are not applicable for closed-circuit cooling towers.~~ The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections.

*Revise Section 12 as follows:*

| Reference | Title |
|---|---|
| CTI ATC-105 (00) | Acceptance Test Code for Water Cooling Towers |
| CTI ATC-105S (96) | Acceptance Test Code for Closed Circuit Cooling Towers |
| CTI STD-201 (04) | Standard for the Certification of Water-Cooling Tower Thermal Performance |

*Revise as follows (SI units):*

**TABLE 6.8.1G Performance Requirements for Heat Rejection Equipment**

| Equipment Type~~d~~ | Total System Heat Rejection Capacity at Rated Conditions | Subcategory or Rating Condition | Performance Required[a,b,c] | Test Procedure~~d~~[d,e] |
|---|---|---|---|---|
| Propeller or Axial Fan Open-Circuit Cooling Towers | All | 35°C Entering Water<br>29°C Leaving Water<br>24°C ~~wb~~ ~~*Outdoor*~~ ~~*air*~~ *Entering wb* | ≥3.23 L/s·kW | CTI ATC-105 and CTI STD-201 |
| Centrifugal Fan Open-Circuit Cooling Towers | All | 35°C Entering Water<br>29°C Leaving Water<br>24°C ~~wb~~ ~~*Outdoor*~~ ~~*air*~~ *Entering wb* | ≥1.70 L/s·kW | CTI ATC-105 and CTI STD-201 |
| Propeller or Axial Fan Closed-Circuit Cooling Towers | All | 39°C Entering Water<br>32°C Leaving Water<br>24°C *Entering wb* | ≥1.18 L/s·kW | CTI ATC-105S and CTI STD-201 |
| Centrifugal Closed-Circuit Cooling Towers | All | 39°C Entering Water<br>32°C Leaving Water<br>24°C *Entering wb* | ≥0.59 L/s·kW | CTI ATC-105S and CTI STD-201 |
| Air-Cooled Condensers | All | 52°C Condensing Temperature<br>R-22 Test Fluid<br>88°C Entering Gas Temperature<br>8°C Subcooling<br>35°C Entering db | ≥69 COP | ARI 460 |

[a] For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 6.8.1G divided by the fan ~~nameplate rated~~ motor nameplate power.

[b] For purposes of this table, *closed-circuit cooling tower performance* is defined as the process water flow rating of the tower at the thermal rating condition listed in Table 6.8.1G divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

~~b~~[c] For purposes of this table, *air-cooled condenser performance* is defined as the heat rejected from the refrigerant divided by the fan ~~nameplate rated~~ motor nameplate power.

~~c~~[d] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

~~d~~[e] ~~The efficiencies for open cooling towers listed in Table 6.8.1G are not applicable for closed-circuit cooling towers.~~ The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections.

*Revise Section 12 as follows:*

| Reference | Title |
|---|---|
| CTI ATC-105 (00) | Acceptance Test Code for Water Cooling Towers |
| CTI ATC-105S (96) | Acceptance Test Code for Closed Circuit Cooling Towers |
| CTI STD-201 (04) | Standard for the Certification of Water-Cooling Tower Thermal Performance |

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## FOREWORD

*Product development for water-cooled chillers in recent years has focused on improving both full-load and part-load performance. Variable-speed drives (VSDs) have gone through significant technology advancements and are now finding application in water-cooled chillers. The use of VSDs shows significant improvement of chiller integrated part-load value (IPLV). Improvements of up to 30% in IPLV are possible. Partially offsetting the part-load performance improvement is a small decrease in full-load efficiency at design conditions, nominally up to 4%. The decrease in full-load efficiency is due to inherent electronic drive losses and power line filters.*

*This addendum establishes—effective January 1, 2010—an additional path of compliance for water-cooled chillers. Path A is intended for applications where significant operating time is expected at full-load conditions. On the other hand, Path B is an alternative set of efficiency levels for water-cooled chillers intended for applications where significant time is expected at part load. Compliance with the standard can be achieved by meeting the requirements of either Path A or Path B. However, both full-load and IPLV levels must be met to fulfill the requirements of Path A or Path B.*

*The addendum also combines all water-cooled positive displacement chillers into one category and adds a new size category for centrifugal chillers at or above 600 tons. The air-cooled chiller without condenser equipment category has been eliminated. All air-cooled chillers without condensers must now be rated with matching condensers. The minimum efficiencies of air-cooled chillers have also been updated. The minimum efficiencies for absorption chillers were left unchanged, as efficiencies have not improved over the last few years and the absorption market has been shrinking, with less than 150 units sold in the US in 2006. Efficiencies in the I-P version of the standard are now expressed in EER for air-cooled chillers, kW/ton for water-cooled chillers, and COP for absorption chillers to reflect industry practices. Tables 6.8.1H through 6.8.1J, listing minimum full-load and NPLV efficiencies of water-cooled centrifugal chillers at nonstandard rating conditions, have been eliminated and replaced by an algebraic equation. The tables will now be included in the 90.1 User's Manual.*

*The effective date of the new efficiency standards is January 1, 2010, to coincide with the phase-out date of HCFC-22 mandated under the Clean Air Act of 1992. This addendum is expected to save 457.6 GWh of energy per year compared to the requirements of ASHRAE/IESNA Standard 90.1-2004. This represents an annual energy saving of 13.3%.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum m to 90.1-2007

*Modify Section 6.4.1.2 as follows (I-P units).*

**6.4.1.2 Minimum Equipment Efficiencies—Listed Equipment—Nonstandard Conditions.** Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.8.1C) of 44°F leaving chilled-water temperature and 85°F entering condenser water temperature with 3 gpm/ton condenser water flow shall have ~~minimum~~ maximum full-load kW/ton ~~COP~~ and ~~minimum~~ *NPLV* ratings ~~as shown in the tables referenced below.~~ adjusted using the following equation:

~~a. Centrifugal chillers <150 tons shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1H.~~

~~b. Centrifugal chillers ≥150 tons and <300 tons shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1I.~~

~~c. Centrifugal chillers ≥300 tons shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1J.~~

Adjusted maximum full-load kW/ton rating
= (full-load kW/ton from Table 6.8.1C)/$K_{adj}$

Adjusted maximum NPLV rating
= (IPLV from Table 6.8.1C)/$K_{adj}$

where

$K_{adj}$ = $6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

$X$ = $DT_{std}$ + LIFT

$DT_{std}$ = (24 + (full-load kW/ton from Table 6.8.1C) × 6.83)/Flow

Flow = Condenser water flow (gpm)/Cooling full-load capacity (tons)

LIFT = CEWT – CLWT

CEWT = Full-load condenser entering water temperature (°F)

CLWT = Full-load leaving chilled-water temperature (°F)

The ~~table~~ adjusted full-load and *NPLV* values are only applicable over the following full-load design ranges:

- Minimum Leaving Chiller-Water Temperature: ~~40°F to 48°F~~ 38°F
- Maximum Condenser Entering ~~Condenser~~ Water Temperature: ~~75°F to 85°F~~ 102°F
- Condenser Water ~~Temperature Rise: 5°F to 15°F~~ Flow: 1 to 6 gpm/ton
- $X \geq 39$°F and $\leq 60$°F

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F or lower for freeze protection are not covered by this standard.

Example: Path A 600 ton centrifugal chiller
Table 6.8.1C efficiencies as of 1/1/2010
Full Load = 0.570 kW/ton
IPLV = 0.539 kW/ton
CEWT = 80°F
Flow = 2.5 gpm/ton
CLWT = 42°F

LIFT = 80 – 42 = 38°F
$DT$ = (24 + 0.570 × 6.83)/2.5 = 11.16°F
$X$ = 38 + 11.16 = 49.16°F
$K_{adj}$ = 6.174772 – 0.303668(49.16) + 0.00629466(49.16)$^2$ – 0.00004578(49.16)$^3$ = 1.020

Adjusted full load = 0.570/1.020 = 0.559 kW/ton
NPLV = 0.539/1.020 = 0.528 kW/ton

*Delete Tables 6.8.1C, 6.8.1H, 6.8.1I, and 6.8.1J in their entirety.*

*Insert new Table 6.8.1C as follows and renumber the remaining tables appropriately.*

**TABLE 6.8.1C Water Chilling Packages—Efficiency Requirements[a]**

| Equipment Type | Size Category | Units | Before 1/1/2010 | | As of 1/1/2010[c] | | | | Test Procedure[b] |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Path A | | Path B | | |
| | | | Full Load | IPLV | Full Load | IPLV | Full Load | IPLV | |
| Air-Cooled Chillers | <150 tons | EER | ≥9.562 | ≥10.416 | ≥9.562 | ≥12.500 | NA[d] | NA[d] | ARI 550/590 |
| | ≥150 tons | EER | | | ≥9.562 | ≥12.750 | NA[d] | NA[d] | |
| Air-Cooled without Condenser, Electrical Operated | All Capacities | EER | ≥10.586 | ≥11.782 | Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements | | | | |
| Water Cooled, Electrically Operated, Reciprocating | All Capacities | kW/ton | ≤0.837 | ≤0.696 | Reciprocating units must comply with water cooled positive displacement efficiency requirements | | | | |
| Water Cooled, Electrically Operated, Positive Displacement | <75 tons | kW/ton | ≤0.790 | ≤0.676 | ≤0.780 | ≤0.630 | ≤0.800 | ≤0.600 | |
| | ≥75 tons and < 150 tons | kW/ton | ≤0.790 | ≤0.676 | ≤0.775 | ≤0.615 | ≤0.790 | ≤0.586 | |
| | ≥150 tons and < 300 tons | kW/ton | ≤0.717 | ≤0.627 | ≤0.680 | ≤0.580 | ≤0.718 | ≤0.540 | |
| | ≥300 tons | kW/ton | ≤0.639 | ≤0.571 | ≤0.620 | ≤0.540 | ≤0.639 | ≤0.490 | |
| Water Cooled, Electrically Operated, Centrifugal | <150 tons | kW/ton | ≤0.703 | ≤0.669 | ≤0.634 | ≤0.596 | ≤0.639 | ≤0.450 | |
| | ≥150 tons and < 300 tons | kW/ton | ≤0.634 | ≤0.596 | ≤0.634 | ≤0.596 | ≤0.639 | ≤0.450 | |
| | ≥300 tons and < 600 tons | kW/ton | ≤0.576 | ≤0.549 | ≤0.576 | ≤0.549 | ≤0.600 | ≤0.400 | |
| | ≥600 tons | kW/ton | ≤0.576 | ≤0.549 | ≤0.570 | ≤0.539 | ≤0.590 | ≤0.400 | |
| Air Cooled Absorption Single Effect | All Capacities | COP | ≥0.600 | NR[e] | ≥0.600 | NR[e] | NA[d] | NA[d] | ARI 560 |
| Water-Cooled Absorption Single Effect | All Capacities | COP | ≥0.700 | NR[e] | ≥0.700 | NR[e] | NA[d] | NA[d] | |
| Absorption Double Effect Indirect-Fired | All Capacities | COP | ≥1.000 | ≥1.050 | ≥1.000 | ≥1.050 | NA[d] | NA[d] | |
| Absorption Double Effect Direct-Fired | All Capacities | COP | ≥1.000 | ≥1.000 | ≥1.000 | ≥1.000 | NA[d] | NA[d] | |

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 40°F.
b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or Path B.
d. *NA* means that this requirement is not applicable and cannot be used for compliance.
e. *NR* means that there are no minimum requirements for this category.

*Modify Section 6.4.1.2 as follows (SI units).*

**6.4.1.2 Minimum Equipment Efficiencies—Listed Equipment—Nonstandard Conditions.** Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.8.1C) of 6.7°C leaving chilled-water temperature and 29.4°C entering condenser water temperature with ~~15.3 l/min·kW~~ 0.054 L/s·kW condenser water flow shall have ~~a~~ minimum full-load COP and ~~a minimum~~ *NPLV* ratings ~~as shown in tables referenced below.~~ adjusted using the following equation:

~~a. (a) Centrifugal chillers <528 kW shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1H.~~

~~b. (b) Centrifugal chillers ≥528 kW and <1055 kW shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1I~~

~~c. (c) Centrifugal chillers ≥1055 kW shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1J.~~

Adjusted minimum full-load COP rating
= (full-load COP from Table 6.8.1C) × $K_{adj}$

Adjusted maximum NPLV rating
= (IPLV from Table 6.8.1C) × $K_{adj}$

where

$K_{adj}$ = $6.174722 - 0.5466024(X) + 0.020394698(X)^2 - 0.000266989(X)^3$

$X$ = $DT_{std}$ + LIFT

$DT_{std}$ = (0.267114 + 0.267088/(Full-load COP from Table 6.8.1C))/Flow

Flow = Condenser water flow (L/s)/Cooling full load capacity (kW)

LIFT = CEWT – CLWT (°C)

CEWT = Full load condenser entering water temperature (°C)

CLWT = Full load leaving chilled-water temperature (°C)

The ~~table~~ adjusted full-load and *NPLV* values are only applicable over the following full-load design ranges:

- Minimum Leaving Chiller-Water Temperature: ~~4.4°C to 8.9°C~~ 3.3°C
- Maximum Condenser Entering ~~Condenser~~ Water Temperature: ~~23.9°C to 29.4°C~~ 39°C
- Condenser Water ~~Temperature Rise: 2.8°C to 8.3°F~~ Flow: .036 to .0721 L/s·kW
- $X \geq 21.7$°C and $\leq 33.3$°C

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of –2.8°C or lower for freeze protection are not covered by this standard.

Example: Path A 2110 kW centrifugal chiller
Table 6.8.1C efficiencies as of 1/1/2010
Full Load = 6.170 COP
IPLV = 6.525 COP
CEWT = 26°C
Flow = 0.05 L/s·kW
CLWT = 5.5°C

LIFT = 26 – 5.5 = 20.50°C
$DT$ = (0.267114 + 0.267088/6.170)/0.05 = 6.208°C
$X$ = 21.11 + 6.208 = 27.319°F
$K_{adj}$ = $6.174722 - 0.5466024(27.319) + 0.020394698(27.319)^2 - 0.000266989(27.319)^3$ = 1.031
Adjusted full load = 6.170 × 1.031 = 6.359 COP
NPLV =6.525 × 1.031 = 6.725 COP

*Delete Tables 6.8.1C, 6.8.1H, 6.8.1I, and 6.8.1J in their entirety.*

*Insert new Table 6.8.1C as follows and renumber the remaining tables appropriately.*

**TABLE 6.8.1C Water Chilling Packages—Efficiency Requirements[a]**

| Equipment Type | Size Category | Units | Before 1/1/2010 | | As of 1/1/2010[c] | | | | Test Procedure[b] |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Path A | | Path B | | |
| | | | Full Load | IPLV | Full Load | IPLV | Full Load | IPLV | |
| Air-Cooled Chillers | <528 kW | COP | ≥2.802 | ≥3.050 | ≥2.802 | ≥3.664 | NA[d] | NA[d] | ARI 550/590 |
| | ≥528 kW | COP | | | ≥2.802 | ≥3.737 | NA[d] | NA[d] | |
| Air-Cooled without Condenser, Electrically Operated | All Capacities | COP | ≥3.100 | ≥3.450 | Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements. | | | | |
| Water Cooled, Electrically Operated, Reciprocating | All Capacities | COP | ≥4.200 | ≥5.050 | Reciprocating units must comply with water-cooled positive displacement efficiency requirements. | | | | |
| Water Cooled, Electrically Operated, Positive Displacement | <264 kW | COP | ≥4.450 | ≥5.200 | ≥4.509 | ≥5.582 | ≥4.396 | ≥5.861 | |
| | ≥264 kW and < 528 kW | COP | ≥4.450 | ≥5.200 | ≥4.538 | ≥5.718 | ≥4.452 | ≥6.001 | |
| | ≥528 kW and < 1055 kW | COP | ≥4.900 | ≥5.600 | ≥5.172 | ≥6.063 | ≥4.898 | ≥6.513 | |
| | ≥1055 kW | COP | ≥5.500 | ≥6.150 | ≥5.672 | ≥6.513 | ≥5.504 | ≥7.177 | |
| Water Cooled, Electrically Operated, Centrifugal | <528 kW | COP | ≥5.000 | ≥5.250 | ≥5.547 | ≥5.901 | ≥5.504 | ≥7.815 | |
| | ≥528 kW and < 1055 kW | COP | ≥5.550 | ≥5.900 | ≥5.547 | ≥5.901 | ≥5.504 | ≥7.815 | |
| | ≥1055 kW and < 2110 kW | COP | ≥6.100 | ≥6.400 | ≥6.100 | ≥6.401 | ≥5.856 | ≥8.792 | |
| | ≥2110 kW | COP | ≥6.100 | ≥6.400 | ≥6.170 | ≥6.525 | ≥5.961 | ≥8.792 | |
| Air Cooled Absorption Single Effect | All Capacities | COP | ≥0.600 | NR[e] | ≥0.600 | NR[e] | NA[d] | NA[d] | ARI 560 |
| Water-Cooled Absorption Single Effect | All Capacities | COP | ≥0.700 | NR[e] | ≥0.700 | NR[e] | NA[d] | NA[d] | |
| Absorption Double Effect Indirect-Fired | All Capacities | COP | ≥1.000 | ≥1.050 | ≥1.000 | ≥1.050 | NA[d] | NA[d] | |
| Absorption Double Effect Direct-Fired | All Capacities | COP | ≥1.000 | ≥1.000 | ≥1.000 | ≥1.000 | NA[d] | NA[d] | |

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 4.4°C.
b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or Path B.
d. *NA* means that this requirement is not applicable and cannot be used for compliance.
e. *NR* means that there are no minimum requirements for this category.

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*Variable-air-volume fan control is currently required in the standard for multiple-zone systems. This proposal extends these requirements for large single-zone units. Important aspects of this proposal include the following:*

- *It applies to both unitary (packaged) equipment and chilled water air-handling units.*
- *It only applies to units with a cooling capacity greater than or equal to 110,000 Btu/h.*
- *The proposal can be met using either two-speed motors or variable-speed drives on the supply fan(s).*
- *The minimum speed requirement is set at 67% fan speed.*
- *It does not take effect until 1/1/2012.*

*This proposal has achieved industry consensus through discussions with AHRI's Large Unitary Engineering (ULE) Group. Three of the criteria were critical to achieving that consensus:*

- *The lower threshold of 10 tons for unitary equipment,*
- *The 2/3 minimum threshold for fan speed, and*
- *The delay in implementation to 2012.*

*The significance of the two-thirds minimum speed threshold is to prevent coil frosting on DX coils (particularly for those units that are face split). The reasoning behind the delay in implementation to 2012 is to allow the AC unit manufacturers time to redesign and test their AC units. All of the manufacturers are currently redesigning their lines to meet the 2010 phase-out of certain refrigerants (R-22). Some have already completed this work for certain product lines. The volume of units being tested for refrigerant change outs is straining the available certified testing resources.*

*Although this requirement does not take effect until 2012, it is believed that manufacturers will begin introducing variable-volume signal-one units in advance of that date. Utility rebate programs, LEED certification, and other incentives should encourage wider demand for these units and will help this requirement to see real savings in advance of the 2012 date.*

*It should be noted that a second proposal is forthcoming to address the budget systems in the Energy Cost Budget Method (see Table 11.3.2A) to make the budget systems 5, 6, 7, 9, and 11 consistent with the requirements of this proposal.*

## Addendum n to Standard 90.1-2007

*Include new item b in Section 6.3.2 as follows. Renumber subsequent section items as appropriate (I-P units).*

**6.3.2 Criteria.** HVAC system must meet ALL of the following criteria:

a. The system serves a single HVAC zone.

b. The equipment must meet the variable flow requirements of Section 6.4.3.10

(c)~~(b)~~. Cooling (if any) shall be provided by a unitary packaged …

*Add new Section 6.4.3.10 as follows (I-P units):*

**6.4.3.10 Single Zone Variable-Air-Volume Controls.** HVAC systems shall have variable airflow controls as follows:

a. Effective January 1, 2010, air-handling and fan-coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 5 hp shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

   1. One half of the full fan speed, or
   2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

b. Effective January 1, 2012, all air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at ARI conditions greater than or equal to 110,000 Btu/h that serve single zones shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

   1. Two-thirds of the full fan speed, or
   2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

*Include new item b in Section 6.3.2 as follows. Renumber subsequent section items as appropriate (SI units).*

**6.3.2 Criteria.** HVAC system must meet ALL of the following criteria:

a. The system serves a single HVAC zone.

b. The equipment must meet the variable flow requirements of Section 6.4.3.10

(c)~~(b)~~. Cooling (if any) shall be provided by a unitary packaged …

*Add new Section 6.4.3.10 as follows (SI units):*

**6.4.3.10 Single Zone Variable-Air-Volume Controls.** HVAC systems shall have variable airflow controls as follows:

a. Effective January 1, 2010, air-handling and fan-coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 4 kW shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

   1. One half of the full fan speed, or

2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

b. Effective January 1, 2012, all air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at ARI conditions greater than or equal to 32.3 kW that serve single zones shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

1. Two-thirds of the full fan speed, or

2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*This addendum is the second phase of correcting the fan power limitation deficiencies of Standard 90.1-2004. The first phase was corrected by Addendum ac to the 2004 standard, which has been approved and is included in Standard 90.1-2007. That addendum addressed all fan systems with exception of those systems serving fume hoods. The reason for excluding fume hood systems was to allow Addendum ac to proceed, correcting a majority of the problems, and be included in the 2007 edition of Standard 90.1. This allowed time to assemble a lab working group that could properly address the needs of laboratory exhaust systems. This working group consisted of three individuals from Labs 21, three design engineers, and one person from the ECB subcommittee. This addendum provides the necessary pressure credits for laboratory exhaust systems that allow prescriptive compliance of these systems.*

## Addendum p to Standard 90.1-2007

*Revise the standard as follows (I-P units):*

*Modify the exceptions to Section 6.5.3.1.1 as follows:*

**Exceptions to 6.5.3.1.1:**

a. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control may use variable-volume fan power limitation.

b. Individual exhaust fans with motor nameplate horsepower of 1 hp or less.

~~c. Fans exhausting air from fume hoods. (***Note:*** If this exception is taken, no related exhaust side credits shall be taken from Table 6.5.3.1.1B and the Fume Exhaust Exception Deduction must be taken from Table 6.5.3.1.1B).~~

*Modify Table 6.5.3.1.1B as follows:*

**TABLE 6.5.3.1.1B Fan Power Limitation Pressure Drop Adjustment**

| Device | Adjustment |
|---|---|
| **Credits** | |
| Fully ducted return and/or exhaust air systems | 0.5 in. w.c. (2.15 in. w.c. for laboratory and vivarium systems) |
| Return and/or exhaust airflow control devices | 0.5 in. w.c. |
| Exhaust filters, scrubbers, or other exhaust treatment | The pressure drop of device calculated at fan system design condition |
| Particulate Filtration Credit: MERV 9 through 12 | 0.5 in. w.c. |
| Particulate Filtration Credit: MERV 13 through 15 | 0.9 in. w.c. |
| Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters | Pressure drop calculated at 2× clean filter pressure drop at fan system design condition |
| Carbon and other gas-phase air cleaners | Clean filter pressure drop at fan system design condition |
| Heat recovery device, biosafety cabinet | Pressure drop of device at fan system design condition |
| Evaporative humidifier/cooler in series with another cooling coil | Pressure drop of device at fan system design condition |
| Sound Attenuation Section | 0.15 in. w.c. |
| Exhaust system serving fume hoods | 0.35 in. w.c. |
| Laboratory and vivarium exhaust systems in high-rise buildings | 0.25 in. w.c./100 ft of vertical duct exceeding 75 ft |
| ~~**Deductions**~~ | |
| ~~Fume Hood Exhaust Exception (required if 6.5.3.1.1 Exception [c] is taken)~~ | ~~−1.0 in. w.c.~~ |

*Revise the standard as follows (SI units):*

*Modify the footnotes to Table 6.5.3.1.1A as follows:*

**TABLE 6.5.3.1.1A Fan Power Limitation***

| | Limit | Constant Volume | Variable Volume |
|---|---|---|---|
| Option 1: Fan System Motor Nameplate kW | Allowable Nameplate Motor kW | kW ≤ $L/S_S \cdot 0.0017$ | kW ≤ $L/S_S \cdot 0.0024$ |
| Option 2: Fan System Input kW | Allowable Fan System Input kW | ~~I~~kW$_i$ ≤ $L/S_S \cdot 0.0015 + A$ | ~~I~~kW$_i$ ≤ $L/S_S \cdot 0.0021 + A$ |

*where

$L/S_S$ = the maximum design supply airflow rate to conditioned spaces served by the system in liters per second

kW = the maximum combined motor nameplate kW

~~I~~kW$_i$ = the maximum combined fan ~~required~~ input kW

$A$ = sum of ($PD \times L/S_D$/ 6500004~~131~~)

where

$PD$ = each applicable pressure drop adjustment from Table 6.5.3.1.1B in Pa~~in. w.c.~~

$L/S_D$ = the design airflow through each applicable device from Table 6.5.3.1.1B in liters per second

*Modify the Exceptions to 6.5.3.1.1 as follows:*

**Exceptions to 6.5.3.1.1:**

a. Hospital, vivarium and laboratory systems ~~systems~~ that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control may use variable-volume fan power limitation.

b. Individual exhaust fans with motor nameplate kW of 0.75 kW or less.

~~c. Fans exhausting air from fume hoods. (*Note:* If this exception is taken, no related exhaust side credits shall be taken from Table 6.5.3.1.1B and the Fume Exhaust Exception Deduction must be taken from Table 6.5.3.1.1B).~~

*Modify Table 6.5.3.1.1B as follows:*

**TABLE 6.5.3.1.1B Fan Power Limitation Pressure Drop Adjustment**

| Device | Adjustment |
|---|---|
| **Credits** | |
| Fully ducted return and/or exhaust air systems | 125 Pa (535 Pa for laboratory and vivarium systems) |
| Return and/or exhaust airflow control devices | 125 Pa |
| Exhaust filters, scrubbers, or other exhaust treatment | The pressure drop of device calculated at fan system design condition |
| Particulate Filtration Credit: MERV 9 through 12 | 125 ~~in w.c.~~Pa |
| Particulate Filtration Credit: MERV 13 through 15 | 225 ~~in~~Pa |
| Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters | Pressure drop calculated at 2× clean filter pressure drop at fan system design condition |
| Carbon and other gas-phase air cleaners | Clean filter pressure drop at fan system design condition |
| Heat recovery device, biosafety cabinet | Pressure drop of device at fan system design condition |
| Evaporative humidifier/cooler in series with another cooling coil | Pressure drop of device at fan system design condition |
| Sound Attenuation Section | 38 Pa |
| Exhaust system serving fume hoods | 85 Pa |
| Laboratory and vivarium exhaust systems in high-rise buildings | 60 Pa/30 meters of vertical duct exceeding 25 meters |
| ~~**Deductions**~~ | |
| ~~Fume Hood Exhaust Exception (required if 6.5.3.1.1 Exception [c] is taken)~~ | ~~250 Pa~~ |

*Modify Section 6.5.3.1.2 as follows:*

**6.5.3.1.2 Motor Nameplate kW.** For each fan, the selected fan motor shall be no larger than the first available motor size greater than the input kW. The fan input kW must be indicated on the design documents to allow for compliance verification by the code official.

**Exceptions to 6.5.3.1.2:**

a.~~e.~~ For fans less than 4.5 kW, where the first available motor larger than the input kW has a nameplate rating within 50% of the input kW, the next larger nameplate motor size may be selected.

b.~~d.~~ For fans 4.5 kW and larger, where the first available motor larger than the input kW has a nameplate rating within 30% of the input kW, the next larger nameplate motor size may be selected.

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*This addendum modifies the vestibule requirements for Climate Zone 4.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum q to Standard 90.1-2007

*Revise the standard as follows (I-P and SI units):*

**5.4.3.4 Vestibules.** Building entrances that separate *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all *doors* opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior *doors* to open at the same time. Interior and exterior *doors* shall have a minimum distance between them of not less than 7 ft (2.1 m) when in the closed position. The exterior envelope of conditioned vestibules shall comply with the requirements for a conditioned space. The interior and exterior envelope of unconditioned vestibules shall comply with the requirements for a semi-heated space.

**Exceptions:**

a. *Building entrances* with revolving *doors*.

b. *Doors* not intended to be used as a *building entrance.*

c. *Doors* opening directly from a *dwelling unit*.

d. *Building entrances* in buildings located in climate zone 1 or 2.

e. *Building entrances* in buildings located in climate zone 3 ~~or 4~~ that are less than four stories above grade and less than 10,000 $ft^2$ (930 $m^2$) in area.

f. *Building entrances* in buildings located in climate zone 4, 5, 6, 7, or 8 that are less than 1000 $ft^2$ (90 $m^2$) in area.

g. *Doors* that open directly from a *space* that is less than 3000 $ft^2$ (280 $m^2$) in area and is separate from the *building entrance*.

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*In Summer 2005, ASHRAE approved addendum g to ASHRAE/IESNA Standard 90.1-2004, which increased the minimum energy efficiency standards of commercial air-cooled air conditioners and heat pumps greater than 65,000 Btu/h. EER and COP (at 47°F) were amended, with new levels taking effect on January 1, 2010. However, IPLV and COP at 17°F were left unchanged.*

*This addendum updates the COP at 17°F efficiency levels for commercial heat pumps and introduces a new part-load energy efficiency descriptor for all commercial unitary products above 65,000 Btu/h of cooling capacity. The new descriptor,* Integrated Energy Efficiency Ratio (IEER)*, is a replacement for IPLV. The IEER is a significant improvement over IPLV as it allows for uniform rating of all products including single- and multi-stage units. It is based on a weighted average of performance at 100%, 75%, 50%, and 25% of capacity. The new part-load metric is expected to more accurately rate the part-load performance of commercial unitary equipment.*

*The IEER and COP at 17°F levels in Tables 6.8.1A and 6.8.1B were derived based on the expected performance of commercial unitary products meeting the new full-load EER and COP at 47°F requirements that will take effect on January 1, 2010. In addition, IEER values are now for product classes with cooling capacities between 65,000 and 240,000 Btu/h, which previously had no IPLV minimums.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum s to 90.1-2007

*Revise the Standard as follows (I-P units).*

*Revise Tables 6.8.1A and 6.8.1B as follows:*

## TABLE 6.8.1A Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

| Equipment Type | Size Category | Heating Section Type | Sub-Category or Rating Condition | Minimum Efficiency[a] | Test Procedure[b] |
|---|---|---|---|---|---|
| Air Conditioners, Air Cooled | ≥65,000 Btu/h and <135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 10.3 EER (before 1/1/2010)<br>11.2 EER (as of 1/1/2010)<br>11.4 IEER (as of 1/1/2010) | ARI 340/360 |
| | | All other | Split System and Single Package | 10.1 EER (before 1/1/2010)<br>11.0 EER (as of 1/1/2010)<br>11.2 IEER (as of 1/1/2010) | |
| | ≥135,000 Btu/h and <240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 9.7 EER (before 1/1/2010)<br>11.0 EER (as of 1/1/2010)<br>11.2 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 9.5 EER (before 1/1/2010)<br>10.8 EER (as of 1/1/2010)<br>11.0 IEER (as of 1/1/2010) | |
| | ≥240,000 Btu/h and <760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 9.5 EER (before 1/1/2010)<br>10.0 EER (as of 1/1/2010)<br>9.7 IPLV (before 1/1/2010)<br>10.1 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 9.3 EER (before 1/1/2010)<br>9.8 EER (as of 1/1/2010)<br>9.5 IPLV (before 1/1/2010)<br>9.9 IEER (as of 1/1/2010) | |
| | ≥760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 9.2 EER (before 1/1/2010)<br>9.7 EER (as of 1/1/2010)<br>9.4 IPLV (before 1/1/2010)<br>9.8 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 9.0 EER (before 1/1/2010)<br>9.5 EER (as of 1/1/2010)<br>9.2 IPLV (before 1/1/2010)<br>9.6 IEER (as of 1/1/2010) | |
| Air Conditioners, Water and Evaporatively Cooled | <65,000 Btu/h | All | Split System and Single Package | 12.1 EER<br>12.3 IEER (as of 1/1/2010) | ARI 210/240 |
| | ≥65,000 Btu/h and <135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.5 EER<br>11.7 IEER (as of 1/1/2010) | ARI 340/360 |
| | | All other | Split System and Single Package | 11.3 EER<br>11.5 IEER (as of 1/1/2010) | |
| | ≥135,000 Btu/h and <240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.0 EER<br>11.2 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 10.8 EER<br>11.0 IEER (as of 1/1/2010) | |
| | ≥240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.0 EER<br>10.3 IPLV (before 1/1/2010)<br>11.1 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 10.8 EER<br>10.1 IPLV (before 1/1/2010)<br>10.9 IEER (as of 1/1/2010) | |

*The remainder of the table is left unchanged.*

**TABLE 6.8.1B Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements**

| Equipment Type | Size Category | Heating Section Type | Sub-Category or Rating Condition | Minimum Efficiency[a] | Test Procedure[b] |
|---|---|---|---|---|---|
| Air Cooled (Cooling Mode) | ≥65,000 Btu/h and <135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 10.1 EER (before 1/1/2010)<br>11.0 EER (as of 1/1/2010)<br>11.2 IEER (as of 1/1/2010) | ARI 340/360 |
| | | All other | Split System and Single Package | 9.9 EER (before 1/1/2010)<br>10.8 EER (as of 1/1/2010)<br>11.0 IEER (as of 1/1/2010) | |
| | ≥135,000 Btu/h and <240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 9.3 EER (before 1/1/2010)<br>10.6 EER (as of 1/1/2010)<br>10.7 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 9.1 EER (before 1/1/2010)<br>10.4 EER (as of 1/1/2010)<br>10.5 IEER (as of 1/1/2010) | |
| | ≥240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 9.0 EER (before 1/1/2010)<br>9.5 EER (as of 1/1/2010)<br>9.2 IPLV (before 1/1/2010)<br>9.6 IEER (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 8.8 EER (before 1/1/2010)<br>9.3 EER (as of 1/1/2010)<br>9.0 IPLV (before 1/1/2010)<br>9.4 IEER (as of 1/1/2010) | |
| Air Cooled (Heating Mode) | ≥65,000 Btu/h and <135,000 Btu/h (Cooling Capacity) | – | 47ºF db/43ºF wb Outdoor Air | 3.2 COP (before 1/1/2010)<br>3.3 COP (as of 1/1/2010) | ARI 340/360 |
| | | | 17ºF db/15ºF wb Outdoor Air | 2.2 COP (before 1/1/2010)<br>2.25 COP (as of 1/1/2010) | |
| | ≥135,000 Btu/h (Cooling Capacity) | – | 47ºF db/43ºF wb Outdoor Air | 3.1 COP (before 1/1/2010)<br>3.2 COP (as of 1/1/2010) | |
| | | | 17ºF db/15ºF wb Outdoor Air | 2.0 COP (before 1/1/2010)<br>2.05 COP (as of 1/1/2010) | |

*The remainder of the table is left unchanged.*

*Add the following in Section 3.2, just above IPLV:*

***integrated energy efficiency ratio (IEER):*** a single-number figure of merit expressing cooling part-load EER efficiency for commercial unitary air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

*Modify the normative reference in Section 12 (under Air Conditioning and Refrigeration Institute) as follows:*

| Reference | Title |
|---|---|
| ARI 340/360-2004~~7~~ | Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment |

*Revise the Standard as follows (SI units).*

*Revise Tables 6.8.1A and 6.8.1B as follows:*

**TABLE 6.8.1A Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements**

| Equipment Type | Size Category | Heating Section Type | Sub-Category or Rating Condition | Minimum Efficiency[a] | Test Procedure[b] |
|---|---|---|---|---|---|
| Air Conditioners, Air Cooled | ≥19 kW and <40 kW | Electric Resistance (or None) | Split System and Single Package | 3.02 COP (before 1/1/2010)<br>3.28 COP (as of 1/ 1/2010)<br>3.34 ICOP (as of 1/1/2010) | ARI 340/360 |
| | | All other | Split System and Single Package | 2.96 COP (before 1/1/2010)<br>3.22COP (as of 1/1/2010)<br>3.28 ICOP (as of 1/1/2010) | |
| | ≥40 kW and <70 kW | Electric Resistance (or None) | Split System and Single Package | 2.84 COP (before 1/1/2010)<br>3.22 COP (as of 1/1/2010)<br>3.28 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 2.78 COP (before 1/1/2010)<br>3.16 COP (as of 1/1/2010)<br>3.22 ICOP (as of 1/1/2010) | |
| | ≥70 kW and <223 kW | Electric Resistance (or None) | Split System and Single Package | 2.78 COP (before 1/1/2010)<br>2.93 COP (as of 1/1/2010)<br>2.84 IPLV (before 1/1/2010)<br>2.96 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 2.72 COP (before 1/1/2010)<br>2.87 COP (as of 1/1/2010)<br>2.78 IPLV (before 1/1/2010)<br>2.90 ICOP (as of 1/1/2010) | |
| | ≥223 kW | Electric Resistance (or None) | Split System and Single Package | 2.70 COP (before 1/1/2010)<br>2.84 COP (as of 1/1/2010)<br>2.75 IPLV (before 1/1/2010)<br>2.87 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 2.64 COP (before 1/1/2010)<br>2.78 COP (as of 1/1/2010)<br>2.69 IPLV (before 1/1/2010)<br>2.81 ICOP (as of 1/1/2010) | |
| Air Conditioners, Water and Evaporatively Cooled | <19 kW | All | Split System and Single Package | 3.54 COP<br>3.60 ICOP (as of 1/1/2010) | ARI 210/240 |
| | ≥19 kW and <40 kW | Electric Resistance (or None) | Split System and Single Package | 3.37 COP<br>3.43 ICOP (as of 1/1/2010) | ARI 340/360 |
| | | All other | Split System and Single Package | 3.31 COP<br>3.37 ICOP (as of 1/1/2010) | |
| | ≥40 kW and <70 kW | Electric Resistance (or None) | Split System and Single Package | 3.22 COP<br>3.28 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 3.16 COP<br>3.22 ICOP (as of 1/1/2010) | |
| | ≥70 kW | Electric Resistance (or None) | Split System and Single Package | 3.22 COP<br>3.02 IPLV (before 1/1/2010)<br>3.25 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 3.16 COP<br>2.96 IPLV (before 1/1/2010)<br>3.19 ICOP (as of 1/1/2010) | |

*The remainder of the table is left unchanged.*

**TABLE 6.8.1B Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements**

| Equipment Type | Size Category | Heating Section Type | Sub-Category or Rating Condition | Minimum Efficiency[a] | Test Procedure[b] |
|---|---|---|---|---|---|
| Air Cooled (Cooling Mode) | ≥19 kW and <40 kW | Electric Resistance (or None) | Split System and Single Package | 2.96 $COP_C$ (before 1/1/2010)<br>3.22 $COP_C$ (as of 1/1/2010)<br>3.28 ICOP (as of 1/1/2010) | ARI 340/360 |
| | | All other | Split System and Single Package | 2.90 $COP_C$ (before 1/1/2010)<br>3.16 $COP_C$ (as of 1/1/2010)<br>3.22 ICOP (as of 1/1/2010) | |
| | ≥40 kW and <70 kW | Electric Resistance (or None) | Split System and Single Package | 2.72 $COP_C$ (before 1/1/2010)<br>3.10 $COP_C$ (as of 1/1/2010)<br>3.13 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 2.66 $COP_C$ (before 1/1/2010)<br>3.04 $COP_C$ (as of 1/1/2010)<br>3.08 ICOP (as of 1/1/2010) | |
| | ≥70 kW | Electric Resistance (or None) | Split System and Single Package | 2.64 $COP_C$ (before 1/1/2010)<br>2.78 $COP_C$ (as of 1/1/2010)<br>2.70 IPLV (before 1/1/2010)<br>2.81 ICOP (as of 1/1/2010) | |
| | | All other | Split System and Single Package | 2.58 $COP_C$ (before 1/1/2010)<br>2.72 $COP_C$ (as of 1/1/2010)<br>2.64 IPLV (before 1/1/2010)<br>2.75 ICOP (as of 1/1/2010) | |
| Air Cooled (Heating Mode) | ≥19 kW and <70 kW (Cooling Capacity) | — | 8.3ºC db/6.1ºC wb Outdoor Air | 3.2 $COP_H$ (before 1/1/2010)<br>3.3 $COP_H$ (as of 1/1/2010) | ARI 340/360 |
| | | | –8.3ºC db/-9.4ºC wb Outdoor Air | 2.2 $COP_H$ (before 1/1/2010)<br>2.25 $COP_H$ (as of 1/1/2010) | |
| | ≥70 kW (Cooling Capacity) | — | 8.3ºC db/6.1ºC wb Outdoor Air | 3.1 $COP_H$ (before 1/1/2010)<br>3.2 $COP_H$ (as of 1/1/2010) | |
| | | | –8.3ºC db/-9.4ºC wb Outdoor Air | 2.0 $COP_H$ (before 1/1/2010)<br>2.05 $COP_H$ (as of 1/1/2010) | |

*The remainder of the table is left unchanged.*

*Add the following in Section 3.2, just above IPLV:*

***integrated coefficient of performance (ICOP):*** a single-number figure of merit expressing cooling part-load COP efficiency for commercial unitary air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment (analogous to IEER, but for SI or other consistent units).

*Modify the normative reference in Section 12 (under Air Conditioning and Refrigeration Institute) as follows:*

| Reference | Title |
|---|---|
| ARI 340/360-2004~~7~~ | Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment |

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*ASHRAE/IESNA Standard 90.1 established a product class for "replacement" packaged terminal equipment to distinguish products intended to replace existing equipment in existing constructions with nonstandard external wall openings from products intended for existing and new construction with standard wall openings (16 in. high × 42 in. wide). However, the term "replacement" has been misinterpreted to mean any packaged terminal equipment intended as a replacement unit regardless of the exterior wall openings it must fit in. Conversely, the term "new construction" has been interpreted as meaning a product intended for new constructions only, while in fact it applies equally to existing and new buildings with standard wall openings.*

*This addendum removes the terms "replacement" and "new construction" from the product classes listed in Table 6.8.1D and replaces them with the terms "nonstandard size" and "standard size," respectively, to clarify that one product class is intended for applications with nonstandard size exterior wall openings while the other is intended for applications with standard size exterior wall openings. The addendum also amends Section 6.4.1.5.2 and footnote b to Table 6.8.1D to clarify that nonstandard size packaged terminal equipment have sleeves with an external wall opening less than 16 in. high* ***or*** *less than 42 in. wide to reflect existing applications where the wall opening is not necessarily less than 16 in. high* ***and*** *less than 42 in. wide. However, to avoid a potential abuse of the definition, nonstandard size packaged terminal equipment are required to have a cross-sectional area of the sleeves less than 670 in.$^2$ (less than 16 × 42 in.).*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum t to 90.1-2007

*Revise the standard as follows (I-P units).*

*Revise Section 6.4.1.5.2 as follows:*

**6.4.1.5.2 Packaged Terminal Air Conditioners.** Nonstandard size p~~P~~ackaged terminal air conditioners and heat pumps with existing sleeves ~~sizes~~ having an external wall opening of less than 16 in. high ~~and~~ or less than 42 in. wide and having a cross-sectional area less than 670 in.$^2$ shall be factory labeled as follows: *Manufactured for ~~replacement~~ nonstandard size applications only: not to be installed in new construction projects.*

*Revise Table 6.8.1D as follows:*

**TABLE 6.8.1D Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps—Minimum Efficiency Requirements**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|
| PTAC (Cooling Mode) ~~New Construction~~ Standard Size | All Capacities | 95.0°F db Outdoor air | 12.5 – (0.213 × Cap/1000)[c] EER | ARI 310/380 |
| PTAC (Cooling Mode) ~~Replacements~~ Nonstandard Size[b] | All Capacities | 95.0°F db Outdoor air | 10.9 – (0.213 × Cap/1000)[c] EER | |
| PTHP (Cooling Mode) ~~New Construction~~ Standard Size | All Capacities | 95.0°F db Outdoor air | 12.3 – (0.213 × Cap/1000)[c] EER | |
| PTHP (Cooling Mode) ~~Replacements~~ Nonstandard Size[b] | All Capacities | 95.0°F db Outdoor air | 10.8 – (0.213 × Cap/1000)[c]EER | |
| PTHP (Heating Mode) ~~New Construction~~ Standard Size | All Capacities | | 3.2 – (0.026 × Cap/1000)[c] COP | |
| PTHP (Heating Mode) ~~Replacements~~ Nonstandard Size[b] | All Capacities | | 2.9 – (0.026 × Cap/1000)[c] COP | |

*The remainder of the table is left unchanged.*

*Revise footnote b of Table 6.8.1D as follows:*

b ~~Replacement~~ Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR ~~REPLACEMENT~~ NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." ~~Replacement~~ Nonstandard size efficiencies apply only to units being installed in ~~with~~ existing sleeves having an external wall opening of less than 16 in. high ~~and~~ or less than 42 in. wide and having a cross-sectional area less than 670 in.$^2$.

*Revise the standard as follows (SI units).*

*Revise Section 6.4.1.5.2 as follows:*

**6.4.1.5.2 Packaged Terminal Air Conditioners.** Nonstandard size p~~P~~ackaged terminal air conditioners and heat pumps with existing sleeves ~~sizes~~ having an external wall opening of less than 0.4 m high ~~and~~ or less than 1.0 m wide and having a cross-sectional area less than 0.4 m$^2$ shall be factory labeled as follows: *Manufactured for ~~replacement~~ nonstandard size applications only: not to be installed in new construction projects.*

*Revise Table 6.8.1D as follows:*

**TABLE 6.8.1D Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single -Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps–Minimum Efficiency Requirements**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|
| PTAC (Cooling Mode) ~~New Construction~~ Standard Size | All Capacities | 35.0°C db Outdoor air | 3.66 – (0.213 × Cap/1000)[c] $COP_C$ | ARI 310/380 |
| PTAC (Cooling Mode) ~~Replacements~~ Nonstandard Size[b] | All Capacities | 35.0°C db Outdoor air | 3.19 – (0.213 × Cap/1000)[c] $COP_C$ | |
| PTHP (Cooling Mode) ~~New Construction~~ Standard Size | All Capacities | 35.0°C db Outdoor air | 3.60 – (0.213 × Cap/1000)[c] $COP_C$ | |
| PTHP (Cooling Mode) ~~Replacements~~ Nonstandard Size[b] | All Capacities | 35.0°C db Outdoor air | 3.16 – (0.213 × Cap/1000)[c] $COP_C$ | |
| PTHP (Heating Mode) ~~New Construction~~ Standard Size | All Capacities | | 3.2 – (0.026 × Cap/1000)[c] $COP_H$ | |
| PTHP (Heating Mode) ~~Replacements~~ Nonstandard Size[b] | All Capacities | | 2.9 – (0.026 × Cap/1000)[c] $COP_H$ | |

*The remainder of the table is left unchanged.*

*Revise footnote b of Table 6.8.1D as follows:*

b ~~Replacement~~ Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR ~~REPLACEMENT~~ NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." ~~Replacement~~ Nonstandard size efficiencies apply only to units being installed in ~~with~~ existing sleeves having an external wall opening of less than 0.4 m high ~~and~~ or less than 1.0 m wide and having a cross-sectional area less than 0.4 m$^2$.

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*Axial fan open-circuit cooling towers use approximately 50% of the energy consumed by centrifugal fan open-circuit cooling towers. Substantial energy can be saved by requiring centrifugal fan units over 1,100 US gpm at the rating conditions to meet the energy efficiency requirements for axial fan units found in Table 6.8.1G. These requirements are 38.0 gpm/hp for axial versus 20.0 gpm/hp for centrifugal, rated at 95°F entering, 85°F leaving, and 75°F entering wet-bulb temperature. This would encourage the current market trend towards lower energy axial fan designs. Exceptions are allowed for sound control and ducted installations (which might be used to reduce the potential for freezing in cold climates). Like-for-like replacements on existing buildings that would require extensive rework of the site (such as to the supporting steel) are permitted under Section 6.1.1.3, Exception b.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum u to 90.1-2007

*Revise the standard as follows (I-P units).*

*Add a new section, Section 6.5.5.3, as follows:*

**6.5.5.3 Limitation on Centrifugal Fan Open-Circuit Cooling Towers.** Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1,100 gpm or greater at 95°F condenser water return, 85°F condenser water supply, and 75°F *outdoor air* wet-bulb temperature shall meet the energy efficiency requirement for axial fan open-circuit cooling towers listed in Table 6.8.1G.

**Exception:** Open-circuit cooling towers that are ducted (inlet or discharge) or require external sound attenuation.

*Revise the standard as follows (SI units).*

*Add a new section, Section 6.5.5.3, as follows:*

**6.5.5.3 Limitation on Centrifugal Fan Open-Circuit Cooling Towers.** Centrifugal fan open-circuit cooling towers with a combined rated capacity of 69.4 L/s or greater at 35°C condenser water return, 29°C condenser water supply, and 24°C *outdoor air* wet-bulb temperature shall meet the energy efficiency requirement for axial fan open-circuit cooling towers listed in Table 6.8.1G.

**Exception:** Open-circuit cooling towers that are ducted (inlet or discharge) or require external sound attenuation.

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*This addendum contains two changes. The first change to the footnote of Table G3.1.1A is to make it clear that Exception a to Section G3.1.1 also applies here. The second change is to the exception to G3.1.2.10 on Exhaust Air Energy Recovery for multifamily buildings because they are unlikely to have a centralized exhaust air system needed to effectively recover heat.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum w to 90.1-2007

*Revise the standard as follows (I-P and SI units).*

*Modify the Notes to Table G3.1.1A as follows:*

**TABLE G3.1.1A *Baseline* HVAC System Types**

| Building Type | Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat | Electric and Other |
|---|---|---|
| Residential | System 1 – PTAC | System 2 – PTHP |
| Nonresidential & 3 Floors or Less & <25,000 $ft^2$ | System 3 – PSZ-AC | System 4 – PSZ-HP |
| Nonresidential & 4 or 5 Floors & <25,000 $ft^2$ or | System 5 – Packaged | System 6 – Packaged VAV w/PFP |
| 5 Floors or Less & 25,000 ft2to 150,000 $ft^2$ | VAV w/ Reheat | Boxes |
| Nonresidential & More than 5 Floors or | System 7 – VAV | System 8 – VAV |
| >150,000 $ft^2$ | w/Reheat | w/PFP Boxes |

**Notes:**
Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.
Where no heating system is to be provided or no heating energy source is specified, use the "Electric and Other" heating source classification.
Where attributes make a building eligible for more than one *baseline* system type, use the predominant condition to determine the system type for the entire building except as noted in Exception a to Section G3.1.1.
For laboratory spaces with a minimum of 5000 cfm of exhaust, use systems type 5 or 7 and reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all electric buildings the heating shall be Electric Resistance.

*Add Exception i to the Exceptions to Section G3.1.2.10 as follows:*

**G3.1.2.10 Exhaust Air Energy Recovery**

…

**Exceptions:** If any of these exceptions apply, exhaust air energy recovery shall not be included in the *baseline building design.*

…

i. Systems serving dwelling units in multifamily buildings.

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## FOREWORD

*A product class for heat pump pool heaters was first established in 2002 and was included in the 2004 version of ASHRAE 90.1. At that time, the minimum coefficient of performance (COP) was based on the test methods and rating conditions contained in ASHRAE Standard 146-1998. The rating conditions in Standard 146 used to rate heat pump pool heaters relied on an outdoor temperature of 80°F and an entering water temperature of 80°F.*

*Since then, the Air-Conditioning, Heating and Refrigeration Institute (AHRI) published ARI standard 1160 "Performance Rating of Heat Pump Pool Heaters," which establishes testing and rating requirements for heat-pump pool heaters. The standard makes reference to ASHRAE 146 for the test methods and provides standard rating conditions at high (80°F) and low (50°F) outdoor temperatures (the entering water temperature being at 80°F). In addition, AHRI has launched a third-party certification program to independently verify the performance ratings (heating capacity and coefficient of performance) of heat pump pool heaters claimed by manufacturers based on ARI 1160.*

*This proposal establishes ARI 1160 as the test procedure for heat-pump pool heaters and requires that the minimum coefficient of performance (COP) of 4 be met at the low outdoor temperature of 50°F (instead of the high outdoor temperature of 80°F currently required). These proposed changes significantly increase the stringency of ASHRAE Standard 90.1, as heat-pump pool heaters will now be required to deliver a COP of 4 at a higher temperature lift. Finally, it should be mentioned that the proposed requirements have been in place for over a year in the state of Florida, which has the largest heat pump pool heater market in the country (http://www.dca.state.fl.us/fbc/thecode/supp_051006icc_corrected0806_eff.pdf).*

## Addendum y to Standard 90.1-2007

*Revise Table 7.8 as follows: (I-P and SI units).*

**TABLE 7.8 Performance Requirements for Water Heating Equipment**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|
| Heat pump pool heaters | All | 50.0°F [10.0°C] db<br>44.2°F [6.78°C] wb<br>Outdoor air<br>80.0°F [26.7°C]<br>Entering Water | 4.0 COP | ~~ASHRAE 146~~<br>ARI 1160 |

*Remainder of table unchanged.*

*Add reference in Chapter 12 and modify as follows: (I-P and SI units).*

| Reference | Title |
|---|---|
| ~~Air-Conditioning and Refrigeration Institute,~~<br>**Air Conditioning, Heating and Refrigeration Institute**<br>**4100 North Fairfax Drive, Suite 200, Arlington, VA 22203** | |
| ARI 1160-2008 | Performance Rating of Heat Pump Pool Heaters |

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## FOREWORD

*Liquid-to-liquid heat exchangers are critical system components used in many buildings covered by ASHRAE Standard 90.1. Applications include, but are not limited to, free cooling with cooling towers, pressure interceptor, water-source heat pump loops, and heat recovery. The proper functioning of these heat exchangers helps to ensure that the energy efficiency of other certified equipment, such as chillers and cooling towers, is fully achieved.*

*A relatively new certification program for ARI Standard 400 is now being widely adopted by this industry. This certification program provides a sound engineering basis for rating the performance of liquid-to-liquid heat exchangers. Inclusion of certification requirements for this equipment will benefit both manufacturers and consumers, allow product comparisons, and provide incentives to manufacturers to improve heat exchanger efficiency in order to gain market share. This program also complements the recently adopted certification requirements for closed-circuit cooling towers (Addendum l to Standard 90.1-2007).*

*As these devices function to efficiently transfer heat between two fluids, no efficiency requirements are listed. Additionally, the cost for the ARI 400 certification program is similar to other ARI Certification Programs, involving thermal tests and the ARI program cost.*

*Lastly, the original Section 6.4.1.4f, addressing Table 6.81G must be deleted based on Addendum ak to Standard 90.1-2004, as requirements for CTI certification were added back in to Table 6.8.1G with that addendum, negating the original paragraph.*

*ARI Standard 400 can be downloaded from the ARI Web site at http://ari.org/NR/rdonlyres/C7CA14D8-B4DD-495C-B8F4-F5A68D8C63E3/0/4002001.pdf.*

*Addendum ak on cooling tower certification can be downloaded from the ASHRAE Web site at http://www.ashrae.org/doclib/20060815_200661121930_347.pdf.*

## Addendum ad to Standard 90.1-2007

*Revise Section 6.8 as shown.*

*Add the following table to Section 6.8:*

*Revise Section 6.4.1.4 as shown.*

**TABLE 6.8.1K Heat Transfer Equipment**

| Equipment Type | Subcategory | Minimum Efficiency* | Test Procedure† |
|---|---|---|---|
| Liquid-to-liquid heat exchangers | Plate type | NR | ARI 400 |

* NR = No Requirement
† Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

**6.4.1.4 Verification of Equipment Efficiencies.** Equipment *efficiency* information supplied by *manufacturers* shall be verified as follows:

a. Equipment covered under EPACT shall comply with U.S. Department of Energy certification requirements.
b. If a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment *efficiency* ratings, then the product shall be listed in the certification program, or
c. if a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment *efficiency* ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report, or
d. if no certification program exists for a covered product, the equipment *efficiency* ratings shall be supported by data furnished by the *manufacturer*, or
e. where components such as indoor or outdoor coils from different *manufacturers* are used, the system designer shall specify component efficiencies whose combined *efficiency* meets the minimum equipment *efficiency* requirements in Section 6.4.1.
~~f. Products covered in Table 6.8.1G shall have efficiency ratings supported by data furnished by the manufacturer.~~
f. Requirements for plate type liquid to liquid heat exchangers are listed in Table 6.8.1K.

*Add the following reference to Section 12.*

## 12. NORMATIVE REFERENCES

| Reference | Title |
|---|---|
| ~~Air-Conditioning and Refrigeration Institute,~~<br>**Air Conditioning, Heating and Refrigeration Institute**<br>**4100 North Fairfax Drive, Suite 200, Arlington, VA 22203** | |
| ARI 400-2001 with Addendum 2 | Liquid to Liquid Heat Exchangers |

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## FOREWORD

*This change recognizes the practical design application of excluding bathroom lighting from "master" switch control in hotel/motel guest rooms and adds a requirement to eliminate wasted light in guest room bathrooms. Recent research shows that approximately 80% of the wasted guest room bathroom lighting can be saved with a 60-minute-limit control device. The 60-minute limit also provides ample time for any potential safety or convenience concerns related to bathrooms, such as the lights turning off too early while the bathroom is still occupied. The 5 W allowance for night lights recognizes the practical current design application of guest room bathroom night light use but at a reasonable low level.*

***Note:*** In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

## Addendum aw to Standard 90.1-2007

*Revise as follows for I-P and SI versions.*

**9.4.1.4 Additional Control.**

g. ~~*Hotel and Motel*~~ *Guest Room Lighting*~~—hotel and motel guest rooms and guest suites shall have a master *control device* at the main room entry that *controls* all *permanently installed luminaires* and switched receptacles~~ Guest rooms in hotels, motels, boarding houses, and similar buildings shall have one or more *control device(s)* at the entry door that collectively *control* all *permanently installed luminaires* and switched receptacles, except those in the bathroom(s). Suites shall have *control(s)* meeting these requirements at the entry to each room or at the primary entry to the suite. Bathrooms shall have a *control device* installed to automatically turn off the bathroom lighting, except for night lighting not exceeding 5 W, within 60 minutes of the occupant leaving the space.

**(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## APPENDIX
## 18-MONTH SUPPLEMENT
## ADDENDA TO ANSI/ASHRAE/IESNA STANDARD 90.1-2007

This supplement includes Addenda a, b, c, g, h, i, j, k, l, m, n, p, q, s, t, u, w, y, ad, and aw to ANSI/ASHRAE/IESNA Standard 90.1-2007. The following table lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE, IESNA, and ANSI approval dates for each addendum.

| Addendum | Section(s) Affected | Description of Changes* | ASHRAE Standards Committee Approval | ASHRAE BOD Approval | IESNA BOD Approval | ANSI Approval |
|---|---|---|---|---|---|---|
| a | 6.8.1G | This addendum seeks to clarify that the current cooling tower requirements in the Standard apply to open-circuit cooling towers only. | 6/23/2007 | 6/27/2007 | 6/12/2007 | 7/25/2007 |
| b | 6.5.2.3 | This addendum updates the references for outdoor ventilation rates. | 6/23/2007 | 6/27/2007 | 6/12/2007 | 7/25/2007 |
| c | 6.5.2.3 | This addendum adds vivariums to the list of spaces that require specific humidity levels to satisfy process needs. | 6/23/2007 | 6/27/2007 | 6/12/2007 | 7/25/2007 |
| g | Section 5, Normative Appendix A2.3 | This addendum updates the building envelope criteria for metal buildings. | 6/21/2008 | 6/25/2008 | 6/30/2008 | 6/26/2008 |
| h | 6.5.2.1 | This addendum adds a new exception that is geared toward zones with direct digital controls (DDC). | 6/21/2008 | 6/25/2008 | 6/30/2008 | 6/26/2008 |
| i | 9.4.5 | This addendum applies a four-zone lighting power density approach to exterior lighting requirements. | 6/21/2008 | 6/25/2008 | 6/30/2008 | 6/26/2008 |
| j | Section 12, Informative Appendix E | This addendum updates references in the Standard. | 1/19/2008 | 1/23/2008 | 1/28/2008 | 1/26/2008 |
| k | Table 6.8.1E, Table 7.8 | This addendum specifies specific sections of reference standards in Tables 6.8.1E and 7.8. | 1/19/2008 | 1/23/2008 | 1/28/2008 | 7/24/2008 |
| l | Table 6.8.1G, Section 12 | This Addendum adds minimum efficiency and certification requirements for both axial and centrifugal fan closed-circuit cooling towers (also known as *fluid coolers*) to Table 6.8.1G. In addition, a reference to ATC-105S, the Cooling Technology Institute test standard for closed-circuit cooling towers, has been added to Section 12, Normative References. | 1/19/2008 | 1/23/2008 | 1/28/2008 | 7/24/2008 |
| m | Section 6.4.1.2, Table 6.8.1C | This addendum establishes effective January 1, 2010, an additional path of compliance for water-cooled chillers and also combines all water-cooled positive displacement chillers into one category and adds a new size category for centrifugal chillers at or above 600 tons | 10/12/2008 | 10/24/2008 | 10/10/2008 | 10/27/2008 |

| Addendum | Section(s) Affected | Description of Changes* | ASHRAE Standards Committee Approval | ASHRAE BOD Approval | IESNA BOD Approval | ANSI Approval |
|---|---|---|---|---|---|---|
| n | 6.4.3.10 | This addendum extends variable air volume fan control requirements to large single-zone units. | 6/21/2008 | 6/25/2008 | 6/30/2008 | 6/26/2008 |
| p | 6.5.3.1.1 | This addendum addresses fan power limitations to all fan systems with exception to those serving fume hoods. | 6/21/2008 | 6/25/2008 | 6/30/2008 | 6/26/2008 |
| q | 5.4.3.4 | This addendum modifies the vestibule requirements for climate zone 4. | 1/19/2008 | 1/23/2008 | 1/28/2008 | 7/24/2008 |
| s | Table 6.8.1A, Table 6.8.1B | This addendum updates the COP at 17°F efficiency levels for commercial heat pumps and introduces a new part load energy efficiency descriptor for all commercial unitary products above 65,000 Btu/h of cooling capacity. | 10/12/2008 | 10/24/2008 | 10/10/2008 | 10/27/2008 |
| t | 6.4.1.5.2, Table 6.8.1D | This addendum removes the terms "replacement" and "new construction" from the product classes listed in Table 6.8.1D and replaces them with the terms "non-standard size" and "standard size," respectively, to clarify that one product class is intended for applications with non-standard size exterior wall openings while the other is intended for applications with standard size exterior wall openings. The addendum also amends Section 6.4.1.5.2 and footnote b to Table 6.8.1D to clarify that non-standard size packaged terminal equipment have sleeves with an external wall opening less than 16 in. high <u>or</u> less than 42 in. wide to reflect existing applications where the wall opening is not necessarily less than 16 in. high <u>and</u> less than 42 in. wide. | 10/12/2008 | 10/24/2008 | 10/10/2008 | 10/27/2008 |
| u | 6.5.5.3 | This addendum adds requirements for axial fan open-circuit cooling towers. | 10/12/2008 | 10/24/2008 | 10/10/2008 | 10/27/2008 |
| w | Table G3.1.1A, Section G3.1.2.10 | This addendum modifies requirements on exhaust air energy recovery for multifamily buildings in Appendix G. | 10/12/2008 | 10/24/2008 | 10/10/2008 | 10/27/2008 |
| y | Table 7.8, Section 12 | This addendum establishes ARI 1160 as the test procedure for heat pump pool heaters and that the minimum COP be met at the low outdoor temperature of 50°F. | 6/21/2008 | 6/25/2008 | 6/30/2008 | 6/26/2008 |
| ad | Table 6.8.1K, Section 6.4.1.4, Section 12 | This addendum adds requirements for liquid to liquid heat exchangers and adds a reference to AARI 400-2008. | 6/21/2008 | 6/25/2008 | 6/30/2008 | 7/24/2008 |
| aw | 9.4.1.4 | This change recognizes the practical design application of excluding bathroom lighting from "master" switch control in hotel/motel guest rooms and adds a requirement to eliminate wasted light in guest room bathrooms. | 1/19/2008 | 1/23/2008 | 1/28/2008 | 6/26/2008 |

* These descriptions may not be complete and are provided for information only.

**NOTE**

**When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.**

## POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.